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TABLE OF CONTENTS:

ENGINEERING NEWS OF THE WEEK.....221, 233
Warwick Castle—A Reminder of the Visit of American Engineers to England (with full-page plate).. 222
The Projected Improvement of the Southwest Pass (illustrated) 222
Weights of Portland Cement and Capacity of Portland Cement Barrels. 229
A Locomotive with "Helping Cylinders" at the Paris Exposition (illustrated) 232
Water Supply Litigation at Menominee, Mich..... 234
The New Covered Water-Works Reservoir at Pittsford, Vt. 234
A New Acetylene Gas Generator (illustrated)..... 235
Nine-Foot Wood Stave Pipe; Floriston Pulp & Paper Co., Floriston, Cal. (illustrated)..... 236
High Hydrostatic Pressures and a New Form of Pressure Gage (illustrated) 236
A Historical Review of Railroad Construction in the United States. 237
An Automatic Coupler for English Freight Cars (illustrated) 240
EDITORIAL NOTES..... 230
The Craze for High Speed in Torpedo Vessels—Squeezing Bacteria to Death—The Bill for a National Bureau of Physical Standards.
EDITORIAL:
A Consolidated Index to Engineering News..... 230
LETTERS TO THE EDITOR..... 232
Making Foundations in Soft Ground Without Piling
The Move for Municipal Ownership of Water-Works in San Francisco—Notes and Queries.

THE CONTRACT FOR THE WACHUSETT DAM has been awarded by the Metropolitan Water Board to McArthur Brothers Co., of Chicago, the lowest bidder. The contract price is $1,603,633. The bids in detail will be found under "Contract Prices," elsewhere in this issue. The dam was described at length in our issue of Sept. 13, 1900.

THE EAST JERSEY WATER CO. formally transferred to the city of Newark, N. J., on Sept. 24, full ownership and control of the water rights and reservoirs in the Pequannock drainage area not previously transferred, together with certain lands incident thereto, 1,000 acres of additional land for the protection of the supply and the duplicate steel pipe line, 21 miles in length. Under the contract made eleven years ago, the East Jersey Water Co., with Mr. Clemens Herschel, M. Am. Soc. C. E., as Chief Engineer, developed a new gravity water supply for Jersey City, with a contract capacity of 50,000,000 gallons a day. The works were put in operation in April, 1892, but in consideration of the right reserved to the company to sell 22,500,000 gallons a day until Sept. 24, 1900, the city paid only $4,000,000 of the full contract price of $6,000,000. Some years later the company built a duplicate pipe line, under a separate contract with the city, materially increasing the conduit capacity. The direct cause for the second pipe line was the failure of the first one to carry the full 50,000,000 gallons. The supplementary contract provided for more than the deficit. A third storage reservoir, the Canistear, has also been built by the company since the original works were completed. The ownership of this reservoir, and of Echo Lake, also in the drainage area, was in question, besides which there were disputes as to whether the contract had been fulfilled as to amount of storage capacity and reservoir sites. The city, not long ago, began a suit to settle all the questions at issue. A compromise was effected, just in time to permit the formal transfer of the balance of the property to the city on the date specified in the cantract, Sept. 24. Mr. M. R. Sherrerd, M. Am. Soc. C. E., engineer of the water department of Newark, has reported, since the transfer, in favor of proceeding to remove the organic matter from the bottom of the Oak Ridge reservoir or to cover it with gravel, work to be started at once.

THE 48-IN. AUXILIARY CAST-IRON WATER MAIN to be laid from Spring Creek to Millburn to supplement the water supply of the borough of Brooklyn, has been authorized by the council, after months of delay and after a mandamus had been issued against the municipal assembly to compel it to concur in bond issues approved by the board of estimate and apportionment. The estimated cost of the main is $1,010,000. We understand that the measure now goes to the mayor for approval.

A 30-IN. WOODEN WATER MAIN across the meadows at Atlantic City, N. J., has been recommended by Mr. Wm. C. Hawley, Assoc. M. Am. Soc. C. E., engineer of the water department. He estimates that such a main would cost $163,288, against $175,000 for riveted steel, and $199,819 for cast-iron pipe. Steel he considers as out of the question, because of the danger of corrosion from salt water. The relatively low weight of the wood pipe is greatly to its advantage, as compared with cast-iron, for laying across the soft, wet meadow land, besides which it is difficult to secure good lead joints for cast-iron pipe in such ground. Mr. Hawley also urges that the wood pipe will have greater carrying capacity than iron at the start, and much greater after the pipe line has been in use a number of years.

A 4-FT. WOOD STAVE PENSTOCK, built of local pine, is being put in at Black Brook, N. Y., for J. J. Rogers & Co., of Ausable Forks. Local pine was used because the company had the lumber on its lands, and also the machinery for working it. The staves were worked out of 3-in. stock. They are jointed at the butts with sheet iron tongues and are banded in the usual way, the bands and shoes being made by the company. The total length of the penstock is 5,700 ft., of which some 5,000 ft. are of wood and the balance of ¼-in. riveted steel, the steel portions comprising 180 ft. at the dam and some 500 ft. at the lower end. The maximum head on the wood pipe is 32 ft. The available head at the power house is about 120 ft., which gives about 550 HP., net. The power will be transmitted electrically about three miles to the pulp mills of the company, located at Ausable Forks. There is a Trump water wheel and a Westinghouse generator, direct-connected, at the power house. The dam across Black Brook, at the head of the penstock, is of masonry, about 600 ft. long over all, very irregular in plan, having two straight ends, not in line with each other, connected by a U-shaped portion, in order to secure a good foundation and avoid a large pot hole. The maximum height of the dam is 30 ft. above the ledge, on which it rests. The dam has been finished and the penstock is nearly so. Mr. E. L. Grimes, of Rutland, Vt., was designing engineer for this work, and laid it out, but the construction is being done under the direction of the company.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Cincinnati Southern Ry. at Sadieville, Ky., on Sept. 21. A freight train broke in two, and when the engine stopped at Sadieville for orders the rear part collided with the head section. A party of tramps were riding on a gondola car in the train, and five of them were killed and six seriously injured.

CIVIL SERVICE EXAMINATIONS for the positions of steel chemist and ornamental iron draftsman will be held by the Municipal Civil Service Commission, 346 Broadway, New York city, on Oct. 15 and 16 respectively. The subjects of each examination will be technical knowledge, arithmetic, experience and handwriting. For further information with reference to these examinations apply to F. G. Ireland, Chief Examiner, and for application blanks apply to Lee Phillips, Secretary.

THE BURNING OFF OF A JOURNAL caused the wreck of a freight train near Danville, Ill., on the Cleveland, Cincinnati, Chicago & St. Louis Ry. on Sept. 20. About 15 cars were derailed, and the track was blocked for five hours.

TRACK ELEVATION AT CHICAGO is to be extended to include the complicated grade crossing at Grand Crossing. Ordinances are being prepared under the direction of Mr. John O'Neill, Superintendent of Track Elevation for the city. It is proposed to elev te the Illinois Central R. R. about 34 ft., and the Lake Shore & Michigan Southern Ry. and Pittsburg, Fort Wayne & Chicago Ry. (which cross the Illinois Central R. R. diagonally) about 12 ft., while the streets will be lowered.

THE NEXT INTERNATIONAL RAILWAY CONGRESS will be held in Washington, D. C., in 1904. A telegram from Mr. W. F. Allen, Secretary of the American Railway Association, announces that the invitation tendered by the American delegates to the congress recently held in Paris, France, has been accepted. The following officials of American railways were in attendance at the recent Paris congress: L. F. Loree, General Manager Pennsylvania Lines West of Pittsburg; J. Ramsey, Jr., Vice-President and General Manager, Wabash; J. T. Harahan, Second Vice-President Illinois Central; C. W. Buchholz, Chief Engineer Erie; S. T. Crapo, General Manager Pere Marquette; C. L. Bretz, General Manager West Virginia Central & Pittsburg; Paul Didier, Assistant Chief Engineer Pittsburg & Western; C. P. Clark, director New York, New Haven & Hartford; P. H. Dudley, Inspecting Engineer New York Central; Dr. C. B. Dudley, Chemist, Pennsylvania; A. M. Gibbs, Assistant Mechanical Engineer Pennsylvania; Col. James L. Taylor, Pennsylvania; Martin A. Knapp, chairman of the Interstate Commerce Commission, and W. F. Allen, secretary of the American Railway Association.

THE RAILWAYS OF NEW SOUTH WALES, on June 30, 1900, aggregated 2,811¼ miles, about 105 miles having been opened during the year, while about 300 miles of pioneer or economic railway are now under construction as development lines. The operating expenses amounted to 55.93% of the earnings. Extensive improvements are being made in the way of reducing grades, eliminating grade crossings, replacing timber trestles with steel structures and installing interlocking plants. New shops have been built, and equipped with modern machinery, and a number of new locomotives have been built, while many passenger cars of the American type are being added to the equipment. The average cost (including shops, rolling stock, etc.) is about $68,435 per mile. The train mileage for the year was 8,894,352 miles; passengers carried, 26,486,873; tons of freight, 5,342,916; tons of live stock, 188,595. The net return per mile of line was $2,540; and the net profit per train-mile was 78 cts. The street railways of Sydney aggregated 71¼ miles, an increase of 5¼ miles, and extensive renewals of rails have been made in view of the gradual introduction of electric traction as a substitute for cable and steam dummy traction. The cost per mile (including shops and rolling stock) is about $135,070; passengers carried, 66,244,344; car mileage, 4,355,024 miles; net return per mile, $5,025; net profit per car mile, 7½ cts.; operating expenses, 83.26% of earnings. Most of the equipment for the electric lines is of American manufacture. All the railways and street railways are owned and operated by the government, under the control of a board of three commissioners. Mr. W. Thow is Chief Mechanical Engineer, and Mr. Thomas R. Firth is Engineer in Chief of the railway. Mr. Geo. Downe is Locomotive Superintendent, and Mr. G. R. Cowdery, Chief Engineer of the street railways.

THE LONDON UNDERGROUND RAILWAY franchise, which was reported in our last issue as having been purchased by an American syndicate headed by Mr. Charles T. Yerkes, of Chicago, Ill., is more fully discussed in recent newspaper dispatches from London. The franchise purchased was that of the Charing Cross, Euston & Hempstead Underground Ry. The price paid was £40,000 (about $200,000). The remaining £60,000 was given in change for a deposit of consols amounting to that sum, which the old company made as a guarantee of good faith and performance of the conditions imposed when Parliament gave the charter.

Associated with Mr. Yerkes in the purchase are Mr. A. A. Housman and Mr. H. C. Davis, of the firm of A. A. Housman & Co., of New York. Mr. Housman is quoted as saying that work will be begun as soon as possible; that the equipment will be of American manufacture, and that the line may be in operation by 1902. The engineer of the railway is Sir Douglas Fox, President of the Institution of Civil Engineers. In commenting upon the project the London "Daily Telegraph" says:

> It is a remarkable feature that a syndicate of Americans should be willing to put down money in advance for the construction of an electric railway for London, which may or may not prove a success. As far as we know, it is the first venture of any magnitude that has been undertaken by Americans in this country. It is somewhat surprising, if they think the risk worth taking, that the scheme has been so long in abeyance owing to lack of sufficient support from English capitalists. There is no doubt that both the Americans and the Germans are a long way ahead of us in the matter of electric traction. There is also the fact that neither the City & South London nor the Waterloo & City line hitherto has proved such a great financial success as was expected. Still, it is curious just at the moment when the new Central London Ry. has made a very successful start, that an American syndicate should have been able to acquire the right of constructing a similar line in another district. We hope that it is not a sign that British enterprise is on the wane, but Londoners may at least congratulate themselves that the much-needed means of communication between Charing Cross and North London will at length be secured by the aid of American capital.

PLANS FOR NEW SEWAGE PURIFICATION WORKS for Manchester, England, have been adopted by the city council. The estimated cost is $2,371,000. This action is particularly interesting because the council finally concluded to carry out the requirements of the Local Government Board, instead of attempting to secure parliamentary sanction for the scheme recommended by its three experts, Messrs. Baldwin Latham, Percy F. Frankland and W. H. Perkin, Jr. The expert's plan provided for open septic tanks and double filtration through contact beds. The Local Government Board insisted on increasing the area of the filter beds by 50% and on supplementing the septic tanks and double filtration by land treatment, or broad irrigation, thus raising the cost from $1,641,190 to $2,371,690. The requirements of the board, as laid down in August of this year, were not so severe as those of October, 1899, which led to a second report by the experts, who clung to their original plan. Moreover, the board gave oral assurance that if experience warranted it they might still further lighten the requirements, after a portion of the work had been carried out.

THE CONSTRUCTION OF AN ICE PLANT at Dawson, Alaska, is reported in a recent issue of "Consular Reports." The idea seems like "carrying coals to Newcastle," but as a matter of actual fact the lack of ice is seriously felt in summer at Dawson, as is witnessed by the price of $100 per ton at which it sold during the past summer. The ice making plant is for a cold storage warehouse, and the contract for the machinery has been let to the McDonal Iron Works Co.

WARWICK CASTLE—A REMINDER OF THE VISIT OF AMERICAN ENGINEERS TO ENGLAND.

(With full-page plate.)

Upon our inset sheet in this week's issue we present something quite different from the usual program of this journal; but which will, we are sure, be especially appreciated by those of our readers whose good fortune it was to be members of the party of American engineers which visited England this summer.

The story of how the visitors to Warwick Castle were received was briefly told in our report of the London meeting of the American Society of Civil Engineers, in Engineering News of July 19 last. In repetition, it may be said that the Institution of Civil Engineers, in casting about for the most pleasurable excursions on which to take the visiting American engineers, selected Warwick Castle among other places of interest. Sir Douglas Fox, the President of the Institution, in announcing the program of meetings and excursions to the visitors, on the opening day of the London meeting, said:

> Then comes Friday. The Countess of Warwick, when she heard we were thinking of taking you to that historic place, said, "By all means; I will receive them at Warwick Castle myself." The Earl and Countess are kind enough to have accepted our invitation to meet you at luncheon in Warwick Park.

We shall attempt no description of the castle. Words can convey slight impression of its picturesque beauty. Even the reproduction on our inset sheet of a photograph of the courtyard gives but a faint hint of the surpassing richness of scene that greets the visitor to this famous stronghold of feudal times, wherever he may turn.

Our readers will be even more interested, we believe, in the portraits which are presented of the Earl and Countess of Warwick. The castle itself, with all its picturesque beauty, was an unimportant feature of the day's pleasure to the American visitors in comparison with the cordial hospitality of their reception by this distinguished nobleman and lady. We are sure the portraits will be a most acceptable souvenir of that occasion to all our readers who were numbered among the guests, and will interest also all American engineers. The reception at Warwick Castle was tendered to the visitors, not as a party of individual strangers but as members of American engineering societies, and was a notable compliment to the American engineering profession.

The same thing may be said, indeed, of all the entertainments provided by the Institution of Civil Engineers for their American visitors. We have chosen Warwick Castle and its gracious host and hostess to present to our readers, however, because the visit to that place was by common consent the crowning feature of the English meeting, and because the cordial hospitality which the Americans there enjoyed deserves no less prominent recognition in American engineering literature than is here accorded to it.

THE PROJECTED IMPROVEMENT OF THE SOUTHWEST PASS.

By William Starling, M. Am. Soc. C. E., M. Inst. C. E., Member of the Southwest Pass Board.*.

Southwest Pass is the extreme right-hand, or western of the three great passes which, with their ramifications, form the delta of the Mississippi River. From the rapidity with which the river pushes its delta into the Gulf, the spaces between the arms or passes have not had time to fill up, as they usually do. The delta is, therefore, still in a rudimentary condition, the passes being isolated one from the other, and each having its own narrow banks, separated from the others by wide expanses of shallow water. Each pass is comparatively wide and shallow at its upper end, and gradually becomes narrower and deeper in its middle part. Toward the mouth it widens again, and when the "land's end" is passed, all traces of distinct banks are lost, and there is a bar of a nearly uniform and very small depth for a width perhaps of two miles.

In the stretch of river immediately above New Orleans, the width at a bank-full stage is about 2,400 ft. and the maximum depth about 120 ft. These dimensions continue substantially unchanged to about the Forts, some 76 miles. Below this point the width increases and the depth diminishes, till at a distance of 3.5 miles below the Forts the width is about 2,600 ft. and the maximum depth less than 90. The river then rapidly shoals and widens to the Head of the Passes, where it is 6,500 ft. wide and has a greatest depth of about 35 ft. The most abrupt change occurs about 4 miles below the Forts. One hundred and fifty years ago there was a great outlet, with branches, just below where Fort St. Philip now stands, called Bayou de Mardi Gras. The levee system, on either side of the river, terminates at the Forts; the land becoming then so low and so narrow that it is not worth protecting. Of the 1,300,000 or so cu. ft. a second which passes New Orleans at time of extreme high water, only about 1,000,000 reach the passes. 160,000 or more go out through Cubitt's Gap, 40,000 through The Jump, and the rest through minor outlets and over the banks.

In 1896, the channel in South Pass was deficient for 139 days. In 1897 it was deficient for 62 days. While it was thought possible to preserve the legal depth of 26 ft. in this pass by dredging, it was not deemed safe to attempt much more. The pass is narrow, and altogether is too small for the long and deep vessels which are constantly coming into use. Consequently the shipowners and others interested in the navigation of the port of New Orleans urged upon Congress the advisability of improving Southwest Pass.

Now Southwest Pass is about four times as large as South Pass. It has a greater velocity, and carries out about five times the quantity of water. The shoal across its head is hardly an obstacle at all, as the least depth which is found in the channel is 30 ft. at low water. The only obstruction of great moment is the bar in the Gulf just outside the mouth of the pass.

Pass a l'Outre has generally been left out of consideration of late years, since the requirement of great channel depths has been pressing. It is not so deep as Southwest Pass, and divides, some 5 miles from its head, into two branches, each of which, in its turn, is subdivided into two more.

Mr. Corthell, in his interesting pamphlet on Maritime Commerce, comes to the conclusion that in 1948 the twenty largest steamships will average 1,000 ft. long, 100 ft. broad and 43 ft. deep. Their loaded draft will be 33 ft. Their speed will be 24 knots an hour, and their tonnage will be 30,000. Even in 1903 they will be 765 ft. long and will draw, loaded, 31 ft., with a tonnage of 24,000. Indeed, there are vessels now afloat and building which already approach these dimensions. In view of this imminent demand for ample proportions of channel, the various great harbors of the world are making preparations to receive even the vessels of 1948. New York already has a channel 35 ft. deep and 1,000 ft. wide, and has advertised for proposals to dredge a channel 40 ft. deep and 2,000 ft. wide. The demand of the New Orleans people is for a least depth of 35 ft.

PROJECT OF THE FIRST BOARD OF ENGINEERS.

In compliance with their request, Congress, early in 1898, passed a joint resolution, authorizing the President to appoint a board of engineer officers of the United States Army, for the purpose of making a survey and report upon the practicability of securing a navigable channel of adequate width and of 35 ft. depth at mean low water of the Gulf, through Southwest Pass. The officers appointed were Colonel Robert, Major Quinn and Major Kingman. Under their direction a comprehensive and thorough survey was made by a party under Mr. Ockerson, M. Am. Soc. C. E., and the results worked up and published with remarkable promptness. The report leaves nothing to desire in abundance of detail and in accuracy. The details embrace topography, hydrography, observations for slope and discharge, and in fact place before the engineer all the knowledge of Southwest Pass which can be conferred by a single survey. There are also slopes and discharges of the other passes, comparative profiles of surveys of other years, showing the advance of bars, etc.

From this survey the board prepared a project and estimates for the improvement of the pass, by a system of parallel jetties, extending from a point in the pass where the width was 2,400 ft. and preserving that distance to the crest of the bar and beyond it to a depth of 30 ft. The shoal, if it can be called such, at the Head of the Passes, was to be deepened by dredging. From East Point, on the left bank, and Stake Island on the right, the jetties were to consist of riprap stone placed upon a heavy foundation mattress, and were to be covered on the sea side by large stones of sufficient weight to resist the action of the waves without being displaced. The mattresses were to have a thickness of compressed willows of not less than 3 ft., and, when sunk, were to be covered with not less than 2 ft. of riprap. They were to be not less than 150 ft. wide. They were to be sunk far in advance of the jetty-construction. To prevent undermining, additional mattresses, 150 ft. square, were to be placed seaward along the channel side of the jetties, and 300 ft. apart.

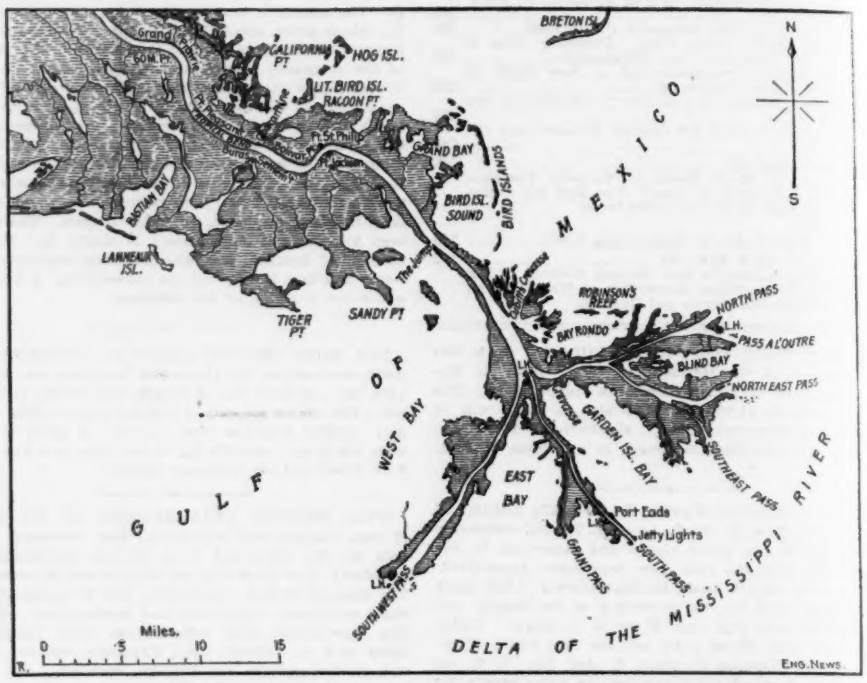

FIG. 1.—MAP OF THE DELTA AND OUTLETS OF THE MISSISSIPPI RIVER.

*Greenville, Miss.

The riprap was to have side-slopes of 2 on 3, after settlement, and a thickness at the low-water line of 30 ft. It was then to be rounded over on the top, so that its crest would be 4 ft. above water-level. The part above water and the exterior slope, within the sphere of dangerous wave-disturbance, was to be formed of large blocks of stone, laid in the form of a pavement. Heavy stone was also to be used at the sea ends and carried up the channel as far as might be thought necessary.

From the land end of the sea jetties, other jetties of lighter construction and different design were to be extended up the pass, so as to maintain the width of 2,400 ft. until this width should be found naturally in the pass. It was thought that for these interior jetties some form of tight sheet-piling would suffice, creosoted and braced and strengthened by ordinary piling. Against this structure, upon either side, dredged material might be deposited until it should be completely covered. In places probably spur dikes would do. From the inner ends of the interior jetties, levees of good profile should be constructed near the river bank. All of the outlet bayous were to be closed, either by the levees or by sheet-piling. A sill should be placed across Pass a l'Outre, 200 ft. wide, of a construction somewhat similar to that of the foundation mattresses.

The board did not think it desirable that these works should be required or expected, of themselves, to secure and maintain the desired depth of water through all the portions of the pass where it is now less than 35 ft. deep. On the contrary, they relied greatly upon the use of powerful dredges, "to assist in the removal of the material and to so guide and direct the current in its action that the channel finally obtained shall be approximately straight and midway between the jetties, and cross the bar at right angles to its crest."

The board was further of opinion that it would be advantageous "so to execute this dredging as to reduce as much as possible the contraction of the waterway resulting from the jetties while in the course of construction, and in this manner reduce to a minimum the shoaling in the pass itself, which might result from the unavoidable disturbance of its regimen." It was expected that the exposure to storms would render the work very expensive, and that settlement to an unknown extent would take place upon the soft and uncertain bottom. It was thought that valuable experience would be gained during the prosecution of the work, and it was recommended that the engineer in charge should not be hampered in his choice of methods and materials, and should not necessarily be required to adhere strictly to the plans of the board. It was desirable that two powerful dredges should be built at the beginning of the work.

The cost of execution was estimated at about $11,000,000, to which about $2,000,000 was added for contingencies. For maintenance, it was thought that 2% of the above sum, annually, would be a sufficient allowance. Provision must be made for bar-advance, which must occur inevitably in the course of time. It was expected that a sinking fund of 1% per annum would provide abundantly for all future extension, and the board was of opinion that a great many years would elapse before any extension at all would be necessary. The board did not apprehend any bad consequences from the lengthening of the pass by the jetties. They thought the narrowing and deepening of the channel would compensate for the flattening of the slope.*

It will be observed that the board were not required to present a matured project, with details of location and construction. All that was desired of them was to make a survey and report upon the practicability of securing a navigable channel of specified dimensions. They had a very short time in which to make their report after the completion of the survey in October. They, therefore, merely showed that the work of improvement was practicable at a cost which was not excessive considering the magnitude of the interests involved.

*Report on Survey of the Southwest Pass, pp. 1-8.

THE SECOND BOARD OF ENGINEERS.

Congress, however, required more particular information before acting definitely on a project for the improvement of the pass; so, by a provision of the Rivers and Harbor bill of March 3, 1899, it was enacted that a board of four engineers should be appointed by the President, of whom at least two should be from civil life, who should prepare a project for securing a navigable channel of the dimensions already specified, with detailed estimates. They were to report especially whether interior jetties were required, and if so to provide for their economical location. The members of the board were Colonel Henry M. Robert and Major G. McC. Derby, M. Am. Soc. C. E., of the Corps of Engineers, and Messrs. Robert Moore and William Starling, Members Am. Soc. C. E., from civil life.

This board has made its report, which has been submitted to Congress and published. It was thought best that the report should be as concise as possible, that it should refer strictly to the matter in hand, and that it should contain but few technical details. For these reasons, it is possible that a paper which should contain a fuller account of the reasons for adopting the particular project presented might posses some interest for the public and especially for the engineering profession.

The work contemplated is one for which there are but few precedents. The conditions existing at the mouth of the Danube, at the mouth of the Maas, at Swinemunde, at Tampico, are widely different from those which are found at the mouth of the Mississippi. It was early recognized that the improvement of the South Pass of the Mississippi afforded the closest analogue to the work in hand, and a careful study was made of the conditions existing there and of the history of the successive stages through which the South Pass improvement has progressed; as well as of the previous work at Southwest Pass and at Pass a l'Outre; during the course of which many interesting and profitable observations were made which have a direct bearing upon the project now in contemplation.

PRESENT CONDITION OF THE PASS.

The admirable survey of 1898 furnished to the board of 1899 the requisite data for the plotting of cross-sections, etc., and the gage-readings and the slope-observations and discharges (which were taken for all the passes) afforded all needed information as to the dynamics of the problem. The following particulars of the regimen of Southwest Pass are taken from the Report of the Survey. It is to be premised that the Head of the Passes, or the intersection of the axes of the three outlets, being the upper end of the shoal existing at that point, is about 6,800 ft., or 1.3 miles, above the zero of Mr. Ockerson's enumeration, which is the Head of the Passes light-house. The soundings of the Survey were reduced to a stage of 21.26 ft. above the Cairo datum, which is the provisional elevation of mean Gulf level found by the Mississippi River Commission. In the map published with the report of the board of 1899 (reproduced on a smaller scale in Fig. 2) they have been reduced to the level of mean low water of the Gulf, the standard adopted by Congress, and these depths have been used in this paper.

For the first two miles below Head of Passes light, the width of Southwest Pass varies from 3,100 to 1,580 ft., and averages 1,890 ft.; then for seven miles the width is quite uniform, ranging from 1,650 to 1,140 ft., and averaging 1,360.

Beginning with the ninth mile, the pass gradually widens out from about 1,400 ft. to 4,300 ft. at East Point. A few sections opposite outlets show widths as great as 4,900 ft. From Head of Passes light to Pilot Town (11.7 miles) the distance between the 35-ft. curves ranges from 730 to 1,580 ft., with an average width of 1,075 ft. Throughout the pass, to a point about 3,000 ft. below Pilot Town, the channel is all that could be wished for. In the thirteenth mile, the 35-ft. channel divides and finally ends at a point 8,000 ft. below Pilot Town (at 13.2 miles). It begins again at a point about 3 miles below Pilot Town (14.9 miles) and continues for a distance of about 4,000 ft. (to 15.7 miles). Below the last-named point the channel flattens out toward the outer crest of the bar (19 miles). The distance from the lower end of the main 35-ft. channel in the pass out to a depth of 35 ft. in the Gulf is 30,200 ft., or 5.7 miles. The distance from the lower end of the lower 35-ft. pool to a depth of 35 ft. in the Gulf is 16,700 ft., or nearly 3.2 miles. The least thalweg depth between the two 35-ft. pools named is 29 ft., and the distance between them is about 9,000 ft. (1.7 miles)."

The sum of it all is that from a point about 0.1 mile below Head of Passes light to 12.6 miles below the same point, there is a maximum depth varying from 40 to 90 ft., and a depth of from 35 to 48 ft. with a bottom width of nearly or quite 1,000 ft. The few exceptional places amount to nothing. Above the Head of the Passes is a shoal about 1.4 miles long, with comparatively little material to remove; from 12.6 to 16 miles there is another shoal, which also will not give much trouble; and from 16 to 19 miles there is a bar with an average depth of about 19 ft. and a minimum depth of about 10. Beyond the crest of the bar, the depth increases rapidly. The 35-ft. contour is only 590 ft. from the 10-ft. contour, and the general slope of the bottom, out to the 100-ft. curve, is about 1 foot in 80.

PREVAILING WINDS AND SHORE CURRENTS.

A matter which is to be considered at a very early stage in the formation of a project for jetties or for harbor improvements of any kind, is the direction of the prevailing winds and currents —as well as of storms or hurricanes. The mouths of the Mississippi are generally considered to lie within the region of the northeast trades, but on its northern margin. Fortunately a nearly continuous record was kept of the force and direction of the wind at Southwest Pass and Pass a l'Outre, for nearly six years, from November, 1871, to June, 1877, inclusive, during the time that the dredge-boats "Essayons" and "McAlester" were at work on the bars.

The easterly winds are (counting from N. to S. S. E.) to the westerly (counting from S. to N. N. W.) as 1,270 to 800, or about as 61 to 39. There is a slight correction to be made here for days not reported, which would make the respective percentages 63 and 38. Not only are the easterly winds the more frequent but they are the more violent. The N. W. wind sometimes blows very hard, but the S., S. W. and W. winds are usually light, and prevail during the summer months. It will be remembered, perhaps, that the hurricanes which destroyed the concrete capping of the jetties at South Pass come from the N. E. and N. N. E., and in the months of September and October.

During all but the summer months, the easterly winds blow for 187 days, while the westerly winds blow 86 days. During summer, the easterly winds blow 39 days and the westerly 53.

The effect of the prevailing easterly winds is to cause a current which sets along shore from east to west. Engineers are generally a little shy about employing the term "littoral current," for there has been a great deal of controversy about the existence of such a current. That there is a "prevailing current," whatever be its origin, is generally admitted, for the evidences of it are manifest in the accumulation of material to the western sides of river mouths and jetties. The current appears to be mainly superficial, for the deposits at considerable depths seem to be little affected by it.

It is well known that the bars at the mouths of rivers are due to two principal causes; the tendency of the sea, under the influence of prevailing winds or of littoral currents, to heap up material in lines parallel to the shore; and the disposition of the river to lay down the load of sediment which it has in suspension as soon as its velocity is checked by its entrance into the sea. It must be remembered, too, that a quantity of material is rolled or carried along the bottom by the stream. This material exerts a modifying influence upon the bar. The tendency of the river to drop its burden of silt is increased by coming into contact with salt water. Some very interesting observations were made, in 1838, by Mr. (afterwards Lieutenant Colonel) Sidell, one of Captain Talcott's assistants in his survey of the mouths of the Mississippi, for the purpose of determining whether the check to the velocity of the river was the sole cause of the deposition of sediment when it encountered the water of the sea. The experimnts showed decidedly that the effect was not owing solely to this cause. Mr. Sidell mingled the turbid river-water, in separate vessels, with seawater, with brine from the salt springs of mud-lumps, with sulphuric acid, and with solutions of common salt, of Epom salt and of alum. "The river-water alone took from 10 to 14 days to settle,

while the solutions became perfectly limpid in from 14 to 18 hours." These experiments were afterwards repeated (in 1883) on a much larger scale, by Professor W. H. Brewer, and in 1886 by Mr. (now Professor) Carl Barus. The last-named observer found that the rapidity of precipitation of solid matter in suspension was affected not only by the presence of saline substances in the water but also by the temperature of the latter. He showed that "acids, salts, alkalis, indeed foreign matter in general, when added to distilled water, permanently turbid with some finely comminuted insoluble solid, in quantities not too large, increase the rate of subsidence in a marked degree, in numerous cases even many hundredfold." He found also that the rate of subsidence was enormously more rapid at 100° Centigrade than at zero. The viscosity of water at 100° is only one-

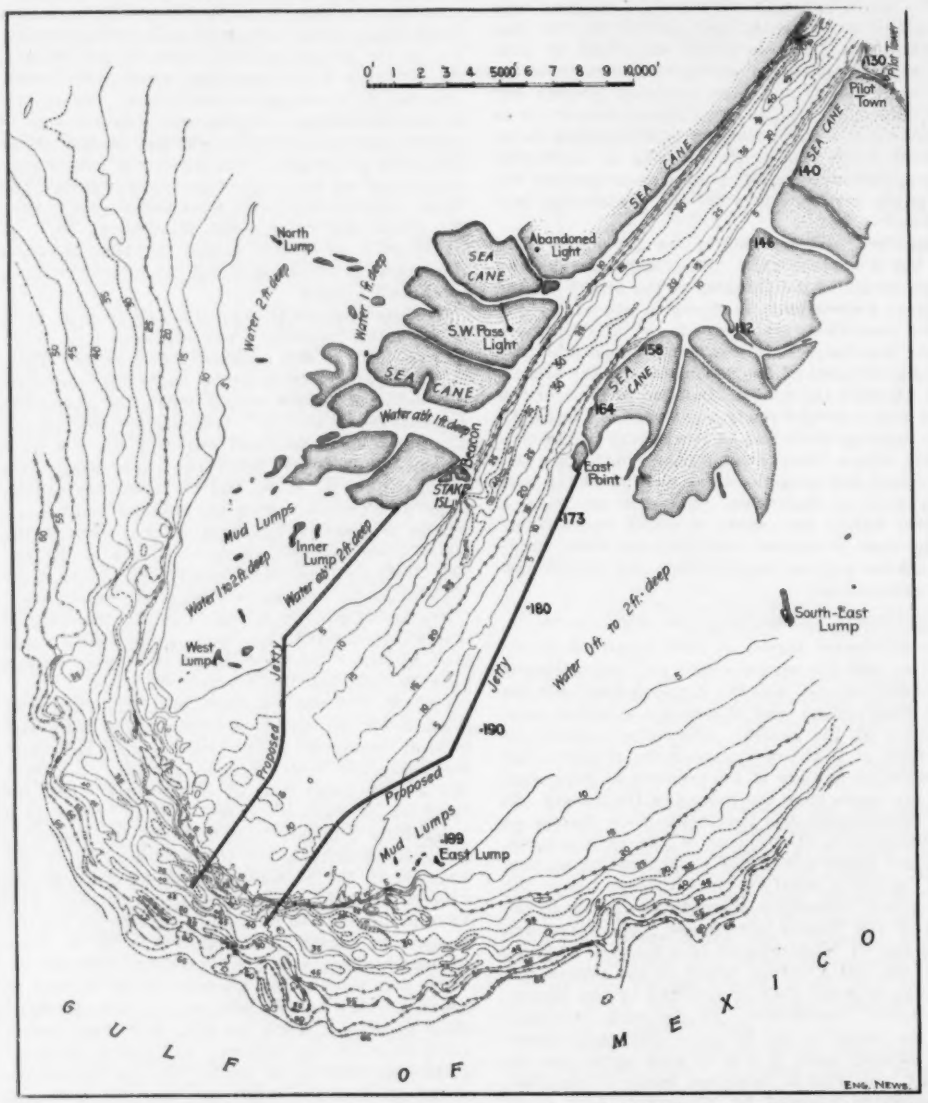

FIG. 2.—MAP OF THE ENTRANCE TO SOUTHWEST PASS, SHOWING LOCATION OF JETTIES PROPOSED BY THE BOARD OF 1899.

believed that the form and the rate of advance of the bar were wholly due to the matter thus pushed. He held that the earth rolled along the bottom of the passes, was checked in its advance when it met what he called the "dead angle" where the fresh water enncountered the heavier salt water, and thus formed the bar. Mr. Eads, on the contrary, from his own experience (in the diving bell) maintained that sand and other sedimentary matters lighter than gravel or the like were carried in suspension, and were not pushed at all. Hence "no such material as forms the bars of the passes is pushed on the bottom of the river in any such quantity as is required to form them, or to serve as a basis for the calculations of bar-advance under the influence of jetties." That there is a large quantity of sand carried along the bottom is clearly shown by the phenomena of sand-waves, as studied by several very competent and accurate observers. Mr. Powless, at Plum Point, thought that not more than 2.5% of the total material carried was rolled or pushed; Mr. Hider, at Lake Providence, thought that the proportion was about 11%; while Captain Leach, at New Orleans, estimated it at less than 1%. There is nothing to forbid the supposition that the proportion so carried may vary in different parts of the stream, with different stages, and with different qualities of silt.

sixth of its value at zero. It is thought, however, that this fact accounts only for a small part of the difference in suspending power.

In the case of an immense sedimentary river like the Mississippi, the effect of the waves and currents of a land-locked sea are of comparatively small consequence, the deposit from the river playing the principal part. The sea, however, does exercise an influence, and an important one, in giving shape to the earthy matters which the river has brought to the spot. The river itself, too, is not idle in the work of modifying its deposits after they are dropped.

With respect to the agency of earth in suspension, as compared with that rolled or pushed along the bottom, there is a very great diversity of opinion. General Humphreys attached a great deal of importance to the pushing movement, and

CHANGES IN THE BAR AT THE MOUTH OF THE PASS.

The bar at Southwest Pass is a true alluvial cone, semicircular in trace and sloping seaward more or less regularly in all directions, somewhat like the half of the crater of a volcano. The slope is much more abrupt immediately seaward of the crest. This peculiarity is not so observable in the surveys of 1838 and 1873. No sign of a definite channel is perceptible after the crest of the bar has been reached. Under the influence of the current, the bar at the mouth of the pass advances into the Gulf. There is little or no doubt that a considerable part of the advance of the crest consists of a transfer of the sandy material from the inner to the outer slope. This is evident, not so much from the fill on the bar, which might be composed entirely of silt deposited from suspension, but from the scour of the inner slope. Taken at the foot of this slope, which may be fixed at the lower end of the lower 35-ft. pool, about 1,000 ft. below Stake Island, the deepening since 1838 in the channel, has been 21 ft.; since 1857, 20 ft.; since 1873, about 8 ft. In 1838, the distance between the two 30-ft. contours was 20,800 ft.; in 1873, 10,500 ft.. in 1898, 13,900 ft. Between 25-ft. contours, in 1838, 15,000 ft.; in 1898, 12,200. Between 15-ft. contours about 9,000 ft. each year.

The scour above the bar has been very great. From one mile above Pilot Town to the foot of the bar below Stake Island, the channel depth has increased by about 15 ft. The advance of deep water in the pass has more than kept pace with the progress seaward of the bar. So in like manner has the narrowing of the pass. In other words, the pass has been developing and extending itself. The rate of advance of the bar has varied exceedingly at different times. From 1838 to 1857 the annual rate of advance of the crest was 239 ft. From 1857 to 1873 it was 401 ft. From 1873 to 1898 it was 176 ft.

The decrease in the rate of advance had been observed by Captain Howell in 1878, and was attributed by him to the increased discharge through Cubitt's Gap, whereby a quantity of water and of silt was withdrawn from the volume previously discharged through the passes. Cubitt's crevasse occurred in 1862. In 1878 it was described as having a deep basin between the river and the subdelta, 112 ft. deep at low water. The maximum depth is now 70 ft. The depth, however, signifies little, as it is the subdelta which controls the flow. The escape of water through the Gap has changed but little, apparently, since Mr. Marindin's survey of 1875. The crevasse in Pass a l'Outre occurred too recently, and has too little effect on the discharge of Southwest Pass to account for the discrepancy. It has at most reduced the outflow of Southwest Pass by less than 4%.

It is possible that the projection of the bar into the Gulf has exposed it more to the action of the littoral or prevailing current from the east, and that thus the accretions on the sea side of the bar have been partially swept away. The advance of the inner crest seems to have progressed with much more rapidity than that of the outer crest. Since 1838, where the outer 35-ft. contour has advanced but 14,400 ft., the inner contour has moved forward 22,200, or at the rates respectively of 240 and 367 ft. a year. Since 1873, the outer 35-ft. curve has moved out 4,000 ft., while the inner has advanced 34,000; or 160 and 1,360 ft. annually. Mr. Ockerson observes:*

> Although the crest of the bar has moved out some 15,540 ft. since 1838, it has not grown in length, but has traveled by the silt being rolled up the rear slope, to be deposited again on the outer slope. In this way the same bar material may have been moved over and over again many times, while the main body of sediment carried by the waters of the pass has contributed to the elongation and expansion of its banks, the banks of its natural branches and the filling-up of the adjacent bays. That is to say, the progression of the bar seaward is not necessarily due wholly to the accumulation of silt brought down by the river, but it might still occur to a certain extent after being once formed, even if the river water were devoid of sediment.

That the bar-advance, however, is not due in any predominant measure to the matter pushed over its crest is evident when we compare the quantity removed from the inner slope to that deposited on the outer. If we examine comparative profiles of 1838 and 1898, we find that there has been removed from the inner slope earth to the depth of about 15 ft., for a length of some 28,600 ft. On the outer slope there has been deposited

*Survey of Southwest Pass, p. 34.

by one agency or another, out to the 100-ft. contour, about 85 ft. of sediment for a distance of 15,500 ft. The areas of these longitudinal sections are 429,200 and 1,317,500 sq. ft.; one is about three times the other. But this is but a small part of the difference. The deep part of the excavation has been only from the thread of the channel—less than 1,000 ft. wide. If we assume that the earth has been removed to a depth of 12 ft. over a width of 2,000 ft., we shall be over the mark. This would give something over 686,000,000 cu. ft. in 60 years—11,400,000 cu. ft. in a year. The deposit has taken place over a large fan-shaped area of unknown extent; not, of course, to the same depth. Southwest Pass carries off something like 2,700,000,000 cu. ft. of solid matter annually; in 60 years, 162,000,000,000—so that the deposit is more than 200 times the excavation. It is said that the bottom, beyond the crest of the bar is very soft. This would increase the probability that this part of the bar is composed, in part at least, of silt dropped from suspension. It is not to be doubted that the heavy matter pushed forward by the current finds also a lodgement there. The outer slope of the bar, indeed, is composed of both elements. A larger part of the light silt is swept away by the winds, tides and currents than formerly—so that the advance of the outer crest is less.

MUD-LUMPS.

There used to be a great deal of discussion of the formations called "mud-lumps." The earliest and most nearly complete description of these curious manifestations is to be found in the report of Mr. Sidell to Captain Talcott in 1838, given as a part of Appendix A to Humphreys and Abbot.

These lumps have a peculiar appearance. In entering the mouth of the river they may be taken for rocks, from their height, the steepness of their sides, their compactness and the appearance of stratification produced by the cracks. In some cases they rise 8 or 10 ft. nearly perpendicularly, and at one place there is a mound in the form of a truncated cone, ascertained to be at least 18 ft. high. The material of the lumps is a fine-grained clay.

On many of these lumps are found springs of salt water. The water issues through a well-defined crater, as firm on the sides as a chimney, generally about 6 ins. in diameter. The surface of the lumps is so hard as to be penetrated with difficulty by a spade. There is an ebullition of the water of the springs at considerable intervals, and inflammable gas escapes, probably light carburetted hydrogen. It is believed that they extend to the original bottom of the Gulf. The water stands in the springs from 2 to 3 ft. higher than the surrounding waters of the river. These lumps vary in size, from mere protuberances to islands of several acres in extent. Pass Island, at the mouth of Balize Bayou, is inhabited and cultivated with success. These lumps and salt springs are only found in the immediate vicinity of the bars, or next to the Gulf. With one exception, the lumps are all found near the mouths of the principal passes. None of these formations exist at the mouth of the South Pass.*

The lumps are swept away by the attrition of the water, and sometimes become the nucleus of shoals, which may in time define the banks of the pass in which they are formed. Rains have also their effect in reducing them to the general level. Hurricanes have been known to sweep away particular lumps at once, and the ebb and flow of the tide of salt water, when the river is low, wears them away more rapidly than the ordinary flow of the river.

According to Mr. (afterwards General) Meade, Captain Talcott's other assistant, they are not formed in the passes, nor could any trace of their previous existence be found. Those in the immediate vicinity of the bar appeared to be more active than the farther removed. There are many of these formations about the mouth of Southwest Pass. Some of them are of considerable extent. "Stake Island," says Mr. Ockerson, "is an old mud lump, grown up with small trees, brush and briers. It seems to be very firm and stable. Some of these lumps are the resting places of myriads of pelicans, gulls, ducks and other fowl."

It was once urged as a serious objection to the improvement of Southwest Pass that the channel over the bar was liable to interruption by mud lumps. Even now, there are submerged lumps which show themselves only during rough weather. They are near the entrance to the pass, and are dangerous to approaching vessels. None of them, however, seem to lie along the line of the main channel, even on or beyond the bar, and none of them are included within the projected jetties or the approaches to them in the Gulf. Mention is frequently made, in the newspapers, of "lumps" in the passes, even in South Pass. These, however, are not mud-lumps. The pilots are in the habit of giving the name "lump" to any mound-like obstruction in the channel, such as may arise, for instance, from the passage of sand-waves. We have seen that mud lumps strictly so-called occur only on the bars, and then generally to the right or left of the main channel. Either they are less formidable than they used to be or undue importance was attached to them in the heated discussions which prevailed in the past.

*This statement must be taken with a little modification. They are rare at South Pass, but they are not unknown.

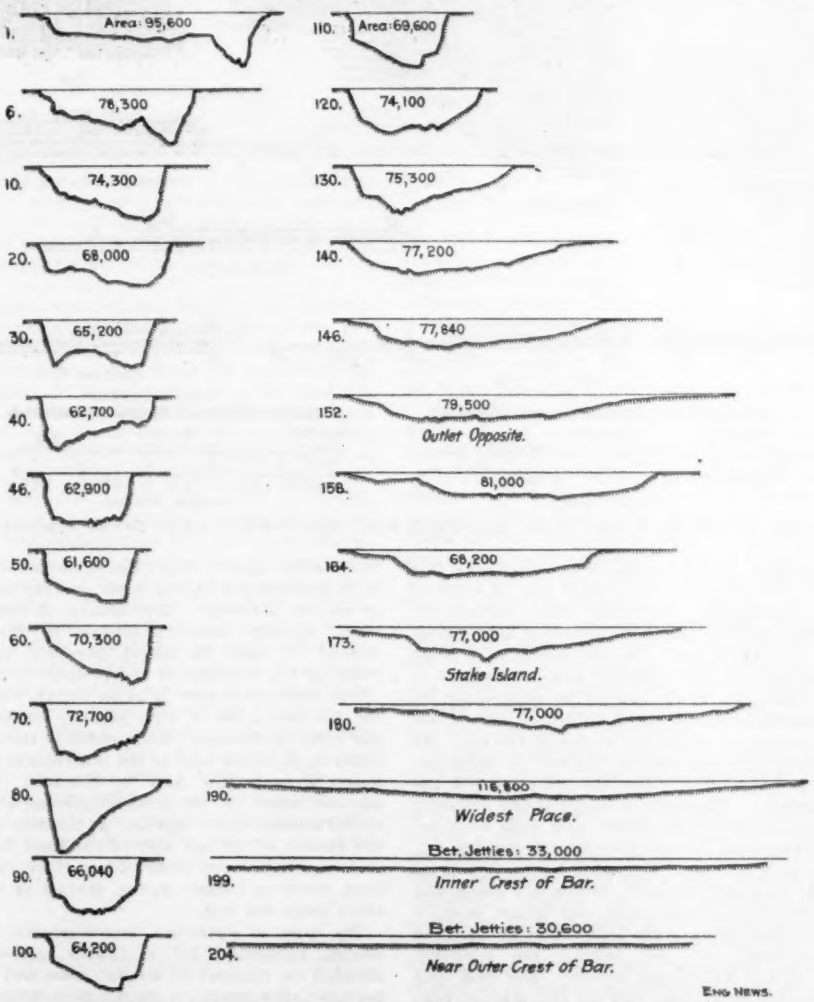

FIG. 3.—TYPICAL CROSS-SECTIONS OF SOUTHWEST PASS.

LOCATING THE JETTIES.

There is an important circumstance which simplifies and facilitates the construction or jetties or protective works at Southwest Pass; and that is the existence of wide flats or shallows on each side of the mouth extending almost to the very crest of the bar. In the case of the East Jetty, this is of peculiar importance, from its much greater exposure. To the east of the line of the proposed pier, at East Point, it is more than two miles to a depth of water of 5 ft.; at 9,000 ft. out from East Point it is about three-quarters of a mile, and this distance is preserved to within 2,000 ft. or so of the end of the proposed jetty. On the greater part of the flats the depth is only from 1 to 3 ft. To the west of the West Jetty the conditions are even more favorable, from the larger accumulation of silt on the lee side of the pass.

Typical cross-sections are given in Fig. 3 from the Head of the Passes to the crest of the bar, from which it will be perceived that for the first two miles below East Point the bottom shallows rapidly on either side from a central width of 2,400 ft. or so, and presently runs out to a depth of only 3 or 4 ft., on the inner slope of the wide flats which have been mentioned.

In the absence of definite instructions as to the width of the channel to be obtained by the projected improvement, the board of 1899 assumed a bottom width of 1,000 ft., with slopes of 1 on 10 up to the natural bottom. It was thought that these dimensions are none too great for the handling and passing of long and deep ships, perhaps in rough weather. It was thought that to secure a depth of 35 ft. which could be depended on, it was best to aim at a depth of 38 ft., wherever the channel was less than 35 ft. for 1,000 ft. wide; and the estimates have been made on that basis.

In considering the means available for securing a channel of such large dimensions through so great a mass of sand and silt, the expedient that most naturally suggested itself was parallel jetties, in conformity with the general practice in such situations, and in accordance with the project of the board of 1898. A pretty thorough discussion of this plan disclosed several objections to it. What is expected of parallel jetties, and what constitutes their peculiar merit, is that they shall obtain and preserve the channel of the required size unaided, or but little aided, by dredging or other external assistance; or, if it be thought expedient, or if it should prove necessary, to employ dredging as an auxiliary in the securing of such a channel in the first place, then the jetties are expected to maintain it.

In the attainment of such a result as this, a first requisite is that the piers should be placed a proper distance apart. The usual method of fixing the distance is by a close observance of the behavior of the pass in its natural state. In the case of South Pass, it was found that the average width above Grand Bayou was about 700 ft., with a depth of 30 ft. or more. As it was intended to close Grand Bayou, it was thought that 700 ft. would be a suitable width between the jetties, being that which the stream itself had developed under the action of the natural forces which were operating upon it. As Mr. Eads, however, expected the tides to exercise a considerable scouring influence, the piers were at first spaced 1,000 ft. apart. So the board of engineers of 1874, in considering a project for the improvement of Pass a l'Outre, adopted as the criterion of width between jetties "the same distance apart as the shore lines of the pass where the required depth

is excavated"—in this instance, 2,200 ft. In like manner, the Southwest Pass Board of 1898 found that at a width of 2,400 ft. the pass, in its natural state, had a depth of 35 ft. and a width at bottom of 800 ft. or so; and they prescribed 2,400 ft. as the space between the centers of the jetties. This appears to be a very proper guide.

The placing of jetties 2,400 ft. apart, however, at the mouth of Southwest Pass, would bring one or both piers, for two miles or so, into deep water; that is, each pier would be, for that distance, in about 16 ft. of water. This would entail an enormous expense in construction; it would render them more liable to attacks by waves and currents; it would necessitate massive methods of construction; and, perhaps, gravest objection of all, it would render the jetties liable to sinking or subsidence in the soft and compresible foundation-soil to an unknown, but certainly to a great extent. These evils would happen even though the jetties were not charged with the duty of forming the channel, but only of maintaining it; but if they were required also to do the work of excavating the passage through the great bar, then another consequence would ensue. The depth of water on the bar, for a length of 3,000 ft., along the channel-line, is, on an average, less than 11 ft. at low water and a little more than 12 at ordinary flood-tide. For a width of 2,400 ft., this depth would give a cross-section between jetties at the mean stage, of only 27,600 sq. ft. The pass has an average section of about 70,000 sq. ft. The bar would act, therefore, as a submerged dam, after the execution of the training-dikes, and would impound the water in the pass to such an extent that the velocity would be reduced to less than one-half of what it had been in the natural state. Therefore, there would be a deposit of sediment throughout the pass of an amount depending upon the stage and condition of the river.

If the ordinary doctrine about transporting power be correct—that when the particles suspended are about of the same size, the suspending power is as the square of the velocities, then a dimunition of the velocity by one-half would decrease the transporting power by three-fourths. If the particles are of the same material but of different sizes the discrepancy in transporting power is enormously increased.

Of course there would be an additional head above the bar, which would cause an increase of velocity, and presently a scour. Recurring, as usual, to the invaluable experience at South Pass, we find that in a year, including a considerable and prolonged flood, the section through the bar increased in area from about 8,000 to 16,000 sq. ft. In four years more, we are informed that the least section through the jetties was 20,000 sq. ft. In the meantime, however, the pass itself had shrunken. It had contracted itself, by diminution of section at the jetties and by consequent reduction of velocity and deposit of silt in the pass; and it has gone on deteriorating even to this day. The channel between the jetties has never enlarged. Each successive contraction of the width, by spur-dikes, interior jetties, etc., has served only to diminish the area of the cross-section, and this, in its turn, has caused a shrinkage of the area of the pass above.

THE INFLUENCE OF DREDGING POSSIBILITIES ON THE JETTY LOCATION.

In all previous works of this kind, dependence had been placed primarily on contraction alone. The river had been made to do its own work—if it would. If it obstinately refused to do so, as at the New Rotterdam Waterway, the dredge was called in, at a great expense, to help out the unwilling stream. Dredging had indeed been done to a great extent, in the estuaries of tidal rivers, like the Clyde and the Mersey. It had been employed with signal success in harbors, as at Calais and at New York. It had not yet been made the principal reliance at the mouth of a great silt-bearing river. In fact, it is only within a short time that it has been cheap enough and efficient enough to justify the engineer in using it as a primary agent in removing enormous and constantly recurring accretions. It has been evident, however, for some years, that the improvements which have lately been made in dredging have introduced a new element into the treatment of river-mouths and harbors, and that the precedents of former times, even of twenty years ago, are not to be closely followed to-day, but are to be regarded only as valuable lessons, to be studied with care and caution, as much for warning as for guidance.

Southwest Pass is now one of the most beautiful natural channels in existence. Even as it stands, with the shoal at its head and the other shoal below Pilot Town, it is large enough and deep enough to accommodate all except perhaps a half-dozen vessels in the world, except for the bar at its mouth. It is proper, it is necessary, to guard by all possible means against spoiling such a magnificent ship-channel; and sudden and violent contraction at its mouth might injure it beyond possibility of repair. If, therefore, it were necessary to place close and parallel jetties at the mouth, it would no doubt be better to build the East Jetty first, and then, under the shelter afforded by it, to dredge out the channel before constructing the West Jetty, with such scour as the river, held from spreading out on one side, might offer. But excessive contraction is by all means to be avoided.

These reasons have militated strongly against the employment of jetties arranged after the conventional pattern On the other hand, jetties of some sort are a necessity. If a channel, when once dredged, would remain open, doubtless this would be the cheapest and easiest way of improving a river-mouth. In purely tidal harbors, or with clear water streams, this method is practicable and is largely used. At the mouth of a great silt-bearing river, the channel, even if dredged to its full capacity, would rapidly be obliterated by the combined action of the sediment of the stream and the action of winds and waves of the sea. As an engineer of experience in this sort of work expresses it, "the river brings the material and the sea shapes it." Moreover, dredges of the ordinary kind, such as are most useful and most economical in river work, cannot generally be used to advantage in a seaway. For such work, vessels of a special type are necesary, which are expensive in construction and operation, and which, in spite of some extraordinary performances which have been recorded, are yet behind the pipe-line dredges of the Mississippi service. For ease and safety of dredging then, and for the sake of preserving the channel after securing it, jetties of some sort are indispensable. By the introduction of the dredge, however, the conditions of the problem are changed entirely.

If dredging is to be the main reliance for developing a channel, then the greater part of the reason for building jetties close and parallel falls to the ground. Such jetties would still be desirable for the maintenance of the channel when once formed, but they are not by any means indispensable. For the sake of economy, then; to obviate the effects of excessive contraction; to guard against excessive subsidence; and for protection against waves and currents; it would appear advisable to place the piers farther apart than ordinary practice has prescribed, and in shallow water. But if in shallow water, then the shallower the better.

In accordance with this reasoning, it is proposed by the project now presented, to begin the jetties at the land's end on either bank, and to follow the depth of 3 ft. or so at ordinary low water, or about 4 ft. at ordinary high water, irrespective of distance apart, for about 9,000 ft. from East Point, then to cross over obliquely to about 10 ft. depth on the east side and 12 ft. on the west, to within about 3,500 ft. of the crest of the bar. After that the jetties are to run straight and parallel and 3,000 ft. apart to the crest of the bar, and perhaps a little beyond. The salient angles are to be eased off by curves. The grade of the top of the crown is to be mean high water of the Gulf. The land extends lower down on the western side. The East Jetty will be 19,950 ft. long; the West Jetty 14,950.

CONSTRUCTION OF THE JETTIES.

The general plan of construction of the jetties is concrete blocks built on a grillage of timber; the whole resting on a mattress foundation except in the shallow water, where the structure is intended to be composed of riprap stone, resting immediately on the mattress. The details of construction have already been published in Engineering News.* It may be useful, however, to explain some of the features of the project:

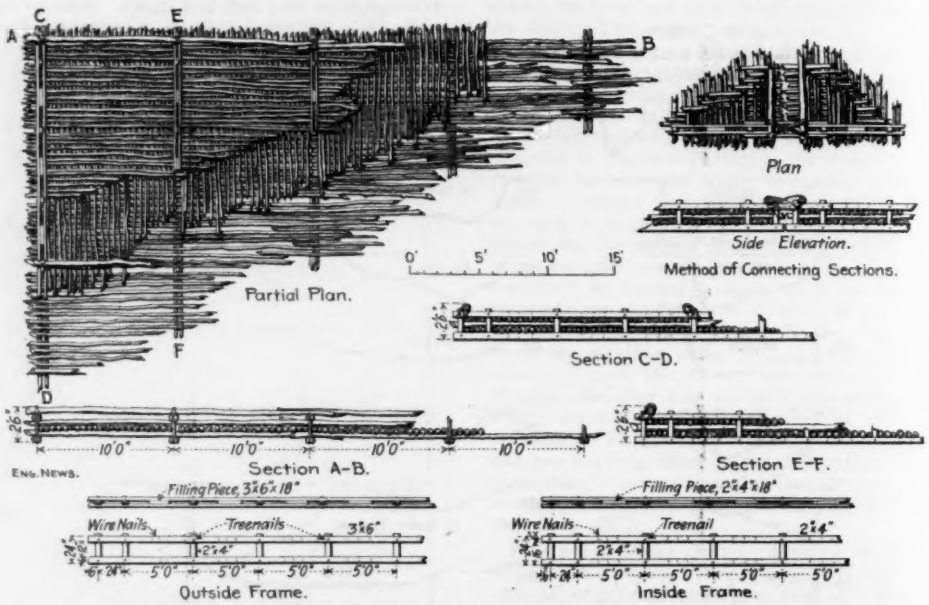

FIG. 6.—FRAMED MATTRESS DESIGNED FOR SOUTHWEST PASS IMPROVEMENT.

The foundation-mat is to be 150 ft. wide except for the last 3,500 ft. (the parallel reach) and for the 1,000 ft. beyond. This width is three or four times as great as that of the mattresses under the South Pass jetties; and is intended to guard against some of the evils experienced in those constructions—first, against a possible scour, in the future, of the sea side of the East Jetty; second, against scour from either river current at high water or racing waves, storms or tidal currents from the sea.

The type of structure recommended, concrete blocks, supported by a timber grillage, was adopted on account of its lightness and its comparative cheapness. A riprap pier, with a crown of 20 ft., which may probably be sufficient in the small depths of the proposed location, and with a height above the mattress of 12 ft., with slopes of 2 on 3, would have a cubic content of 456 cu. ft. per running foot, and would weigh in water (at 60 lbs. per sq. ft. of foundation) 27,360 lbs., or 480 lbs. per running foot. It is estimated that a weight of 300 lbs. per square foot of foundation will cause a subsidence of about 4 ft. If this assumption be correct, then the riprap mound, with the weight stated, would sink into the mud 6 ft.

*Feb. 15, 1900.

or more, including 3 ft. of mattress; which, in 10 ft. at low water, would bring the crown of the jetty 1 ft. below low water, or rather more than 2 ft. at high water. The wall then would have to be about 17 ft. high. A wall of this height would weigh, per running foot, 46,510 lbs., or 655 lbs. per sq. ft., which would sink mattress and jetty about 8.7 ft., bringing the crown 0.2 ft. above high water. We should, therefore, have built 17 ft. of expensive construction for a net effect of about 11 ft.

For the same depth (10 ft. at low water, or 11.1 at high water) a concrete block 11.3 ft. high, with a crown of 9 ft. and slopes of 2 on 1, supported by a mattress and a grillage, each 2 ft. in thickness, the grillage 44.1 ft. wide, would weigh (at 80 lbs. in water) 13,244 lbs., or 300 lbs. on each sq. ft. of mattress. This would secure a settlement of about 4 ft.; that is, the mattress and grillage would both be buried in the mud, and the concrete block would project its whole height above the bottom. In other words, it would be the cheaper material that would be lost. By reason of this subsidence, the mattress and grillage would not be subjected to the attacks of the teredo.

The grillage is interposed between the concrete and the mattress for three reasons: First, for lightness; second, for cheapness; third, for stiffness, so that it may distribute the weight of the concrete over the foundation. In order that the weight of the concrete may be equally distributed according to the standard fixed (300 lbs. to the sq. ft., weighed in water), the grillage must be of variable width. A block of 8 ft. crown, 8 ft. depth and slopes of 2 on 1, will contain 96 cu. ft. to the running foot, and will weigh, in water, 7,689 lbs. The grillage then will have to be 25.6 ft. wide. A block of 9 ft. crown and 11 ft. depth will weigh, in water, 12,760 lbs., and the grillage will be 42.3 ft. wide. The base of the block is 20 ft., leaving a projection or offset on each side of the block of 11.15 ft. Will this be safe? Will the grillage stand it without breaking? The upper or transverse tier of the grillage is asumed to be solid; that is, the timbers are laid touching one another. It is this tier which stands the strain. Hence the problem is that of a beam 1 ft. square and 42.3 ft. long supporting a load of 12,760 lbs.

This load is supposed to be sufficient to sink the structure 4 ft. into the ground. When it reaches an equilibrium, and during the sinking, we shall

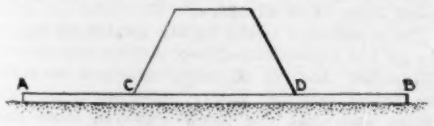

Fig. 4.—Diagram Illustrating Bending Stresses on Grillage Under Concrete Pier.

have the beam firmly held in place, Fig. 4, at C and D by the weight of the block and the reaction of the ground. From A to C and from B to D it will be acted on by the reaction alone, namely, 300 lbs. to the sq. ft. It is, therefore, the case of a beam fixed at one end and uniformly loaded—the load acting upward, however. In this way, the allowable length of beam or cantilever which should support its load of 300 lbs. to the sq. ft., with a factor of safety of 6, would be 15.5 ft.; with a factor of safety of 8, 13.5 ft. The greatest actual projection of the grillage is 13.5 ft., and this only once. Usually it is less than 10 ft. When the projection exceeds 13.5 ft., another tier of grillage is interposed; which, as it is not expected to sink into the mud, is creosoted as a protection against the teredo.

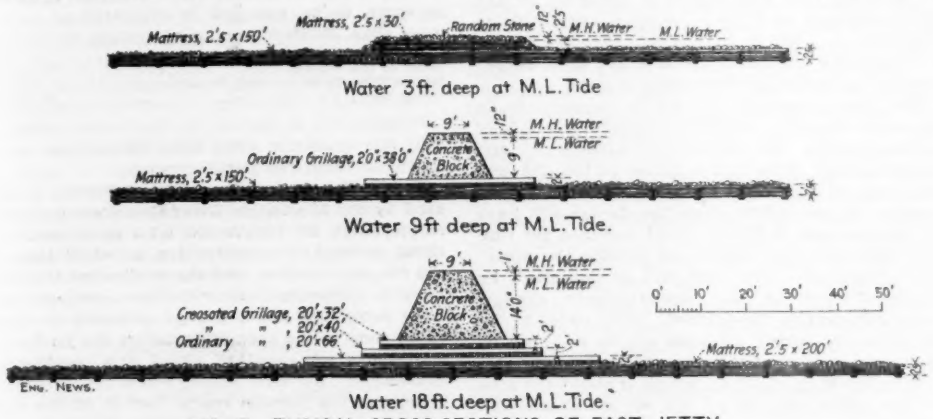

FIG. 7.—TYPICAL CROSS-SECTIONS OF EAST JETTY.

WAVE ACTION ON THE JETTIES.

The blocks are to be built as heavy as they can be handled. It may be remembered that blocks wenghing 100 tons or more were displaced by great storms at South Pass. This was partly owing to the vertical faces of the blocks and partly to their high grade, 4 ft. or so above the water. In the projected structure, it is intended to build the blocks with a batter of 2 on 1 (that is, 1 base and 2 altitude) and only to a high-water grade.

With the wide flats protecting the jetties on either side, it is not anticipated that great waves will attack the works, except, perhaps, at the exreme sea-ends. Even here, the jetties are fairly protected, by the mainland and the projection of the other passes into the Gulf. We have seen that the northeast is the quarter from which the heaviest storms have come hitherto. The greatest safeguard, however, is probably the low grade. It is well known that the force of waves is principally exerted above the water-level, and that it is comparatively small at that level. A jettied channel is not intended to be a harbor of refuge, nor is a jetty necessarily a breakwater. It is the testimony of the owners and commanders of ships that a swell in the channel is not of great consequence unless it be so considerable that there is danger of the bottom of the vessel striking the ground. While the winds of the Gulf are sometimes violent, the waves have a comparatively short fetch, and no such structures are necessary as are built on the North Sea or the Indian Ocean. Even in the former location, the jetties at the mouth of the Maas (the New Rotterdam Waterway) were built only to a high-water grade, and it is to this circumstance that their successful and economical maintenance is principally due. It was proposed, at one time, to raise the grade; but this has never been done.

The main objection to low jetties is that the sea, in storms, may throw large quantities of sand over the walls, which material has to be removed in some way. It was partly with a view of providing a remedy for this evil that the "inner jetties" were built at the mouth of South Pass 4 ft. above sea-level. It is not a very serious matter, however. Storms are not frequent—at least storms of such violence as to throw considerable volumes of solid matter into the channel. Dredging, too, is now cheap, and the cost of the removal of any such intrusive sediment would be a mere trifle, compared with the addition of cost, weight, liability to subsidence and vulnerability to storm-action entailed by a grade several feet above high water.

CROSS-SECTIONS AND VELOCITIES IN THE NEW CHANNEL.

At East Point the projected jetties are about 3,700 ft. apart; a little below Stake Island, about 4,500; at the widest place, where the two re-entrant angles are opposite one another, about 7,500; through the parallel reach, 3,000 ft. After the channel is dredged to its proper dimensions, the areas of the cross-sections will be, at these points:

East Point	82,000 sq. ft.
Below Stake Island	81,200 " "
Widest place	116,800 " "
Parallel reach	70,800 " "

The average cross-section of the pass is about 70,000. In the very narrow and deep places it is sometimes as little as 62,000. In the wide places, it approximates 75,000.

The question at once arises: Will not the excessive section in the very wide reach between the jetties cause a check to the velocity, and consequently an immediate fill in that place, and will not the dredged channel be speedily obliterated? It is not doubted that there will be a fill in the places referred to, but it is thought that it will not interfere seriously with the preservation of the central channel. At the widest place (about station 190 of Mr. Ockerson's survey) the maximum depth after dredging will be 38 ft., for a bottom width of 1,000 ft. Then there will be an average depth of 28 ft. for 400 ft., of 19 ft. for 1,000 ft., of 13.5 ft. for 2,400 ft., and of 6 ft. for 2,700 ft. According to the received formula, the slope being the same, the velocities will be as the square roots of the depths, and we shall have, for a flood-discharge of about 375,000 cu. ft. per second (the greatest observed by Mr. Ockerson):

38,000 sq. ft. of cross-section, with a velocity of 4.3 ft. per second, per second	166,400 cu. ft.
11,200 sq. ft., with velocity of 3.7	41,440 " "
19,000 sq. ft., with velocity of 3.0	57,000 " "
32,400 sq. ft., with velocity of 2.6	84,240 " "
16,200 sq. ft., with velocity of 1.6	25,920 " "
116,800 sq. ft. of cross-section, with a discharge of	375,000 " "

The slope will not be the same. It will be less on the flats, for there will be a loss of head when the water escapes laterally from the deep channel into the shallows, and again where the water re-enters the channel, near the beginning of the parallel reach below. It is probable that the velocity in the channel will be three times the velocity in the flats of 6 ft. depth; and that the main portion of the deposit will be adjacent to the jetties, where it is most wanted. Even in the depth of 13 ft. or so, there will no doubt be a considerable fill. It must occur somewhere in the cross-section. The sudden transition from a mean velocity of 5 or 6 ft. per second to 3.2 (the mean velocity of the widest section) will infallibly cause a silting-up; but it will occur least where the current is greatest; to wit, in the central channel.

It is not asserted that there will be no deposit in the dredged channel. It may be that enough material will be dropped there to require the use of the dredge occasionally for several years. But it is asserted that the bank will gradually build itself up, and little by little contract the channel to its proper dimensions. It is estimated that it will take something like five years to complete the work. In that time the building process ought to have made considerable progress. These deductions are perfectly sound in principle, although the data are not numerous enough or accurate enough to enable us to draw quantitative conclusions from them. They are abundantly borne out by the history of the development of the passes as is written in the cross-sections of the different reaches.

THE EVOLUTION OF THE PASS.

In 1747, Southwest Pass was 10 miles long, from the Head of the Passes to the land's end on either side. Where Pilot Town now is, was a bar such as now exists 17 miles below that point.* Even as late as 1873, what is now East Point, 1,880 ft. above Stake Island, was then in the open Gulf, the land's end on the east side being more than two miles above Stake Island. The latter, being an old mud lump, is apparently undisturbed by all these changes, and constitutes an admirable reference-mark for comparisons of different surveys. The pass has, therefore, been developed or evolved, little by little, out of the bar, and the process of transformation is going on now, under our eyes. Of the typical cross-sections shown in Fig. 3, the one marked 204 was taken at a point about 2,000 ft. above the outer crest of the bar. It exhibits very little sign of a channel. No. 190 shows the upper end of the parallel reach. No. 190 represents the section at the widest place; No. 180, a section nearly a mile above; 173 the Stake Island section. Going up the pass, we have sections

*See an old map, in Corthell, History of the Jetties, p. 8.

164, 158, 152, 146, 140, about half-a-mile apart. Section 130 shows the type dying out. Section 120 shows the entire extinction of the lateral flats which have been so conspicuous a feature of the previous sections. The pass is now reduced to a width of 2,200 ft. At 110 it is only 1,750 ft. wide, and the area is only 69,600. At 100 it is 1,300 ft. wide, and its area is 64,200. From this point to station 46 the sections present different varieties of a deep and narrow pass, never more than 1,500 ft. wide, and sometimes as little as 1,200, with an extreme depth of 90 ft. or more; sometimes symmetrical, showing the channel in the center, sometimes steep on one side and flat on the other, showing a tendency of the channel to hug one side, namely, the concave side of a bend. The pass is thus seen to be a series of reverse curves, as indeed it appears on the map. From station 46, the pass gradually becomes wider and shallower, and, on the whole, of greater area till the Head of the Passes is reached, when it expands, by degrees, into the open river.

The history of the development of the pass is written plainly in these significant traces. The central thread of current had gradually pushed its way forward and built up its banks by lateral outflow, on either side. As the banks made their way into the open Gulf they, in their turn, concentrated the waters, gave the current greater power, and its efforts were better directed. Instead of spreading itself all over the bar, it made its attack in a limited space and with new vigor. Thus, as the bar pushed ahead, the pass kept pace with it, and even surpassed it in the race.

The crest of the bar is always in this shape, shown by Fig. 5, the radius of the semicircular section of the half-cone, at 24 ft. depth, being about 3 miles. There is a tongue of deep water projecting into the bar—the 16-ft. contour in this instance—while on each side the pass shallows off to 6 and eventually to 2 ft. or less. Of course the

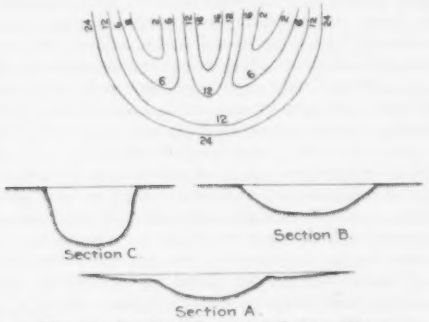

Fig. 5.—Typical Form of Ocean Bar.

deposit takes place first in the shallowest water; and after the bottom there has been brought nearly to the water-level, it fills in the rest of the flats. In the beginning the section was of the type shown in A, Fig. 5, then it takes the form B; after this, it is slower work filling up the shallower places. The current is swifter, and there is less difference between the channel velocity and that near the banks. Still, the sections go on contracting. In 1838, the width at Pilot Town was about 3,800 ft.; in 1873 it was about 2,800; in 1898 it was about 2,500. At first, the movement was at the rate of nearly 30 ft. a year; now it is at the rate of about 12.

Gradually the section becomes narrower and deeper, and approximates to the shape C, until the favorable form of the section enables the water to attain the requisite velocity with less slope. But if the slope be less than the normal in this reach, it must be greater above it or below it or both. Consequently, those reaches must assume a wider and shallower form, according to a general law of streams with movable beds.

To verify this law by example, we see* that the slope from station O to station 48 is at the average rate of 0.16 ft. to the mile; from 48 to 102 at the rate of 0.09; and from 102 to Stake Island it is 0.14. From 0 to 48 the average width is 1,614 ft.; from 48 to 102 is is 1,300; and from 102 to Stake Island it is 2,460, excluding the flats of small depth. The last stretch is wider and shallower than usual, because it has not reached its full development, but is yet in a state of transition from bar to pass.

*Ockerson, Survey of South Pass, p. 30.

APPLICATION TO THE IMPROVED CHANNEL.

This process will go on in the wide reach between the jetties. First the flats on each side from 3 to 9 ft. will be filled up, reducing the maximum width to about 4,800 ft., and the cross-section to 100,000 sq. ft. At the same time a slower fill will be progressing in the partial area from 9 to 18 ft., by which the area will be reduced still more. By the time the jetties are completed, it is believed that the shallower spaces first alluded to would become so nearly dry land as to bear a growth of swamp-grass and reeds, even were there no other action than that of the river. That the central channel will nearly maintain itself is borne out by the experience at the mouth of South Pass; where the current issuing from between the jetties has maintained a channel through the bar, cutting directly through the 30-ft. contour, and has caused a recession of the other contours, up to 80 ft. or more, amounting to from 500 to 1,500 ft. in length. In other words, it preserves a channel something like 10 ft. deeper than the adjacent bar, for nearly 2 miles.

The river, however, will not be required to do its work unaided. It will be assisted powerfully by the dredges. The office of the latter is not only to give depth, form and location to the channel, but also, by deposit of the spoil, to build up the banks. At the widest place, the dredge will have to remove some 24,400 cu. ft. of material per running foot from the channel to provide the necessary waterway. The spoil will be deposited, by means of pipes, in the comparatively shallow water adjacent to the channel. This, added to the 16,000 cu. ft. which we hope will be built up by the natural action of the river, will reduce the section to 75,000 sq. ft. or so, which is about the area of the wider reaches of the natural pass, and which is the area necessary to pass the discharge of 375,000 cu. ft. per second at a mean velocity of 5 ft.

Of course the dislodged material will not be deposited so close to the channel that there will be danger of its returning, in large proportion, to the place whence it came. The inclination of the bottom adjacent to the channel, toward the shore, is 9 ft. in 1,200, or 1 in 134. The dredging, in this part of the reach, will be done mostly at low water of the river, when the velocity is very small (at flood tide it is almost nothing) and it is hoped that the greater part of the spoil will remain in place. Should it be found that the fill takes place too slowly, and that the dredges are unable to keep the channel clear without undue expense, the process of building up the banks may be hastened by the use of "silt-catching" spurs projected from the jetties. These may be of the permeable type, so largely and successfully used on the Mississippi and Missouri, but of lighter and cheaper construction—consisting of rows of piles driven through foot-mats, and wattled, if necessary, with brush at intervals. It is thought, however, that these adjuncts will not be required. Should they be used, it will not be necessary to creosote the piles, as the water will be mostly fresh. Furthermore, the piles are intended to answer only a temporary purpose. They will soon be buried beneath the deposits. When the banks are built up by these means, we shall have a channel of the requisite dimensions within the jetties, down to the parallel reach.

The reason that the jetties are brought so close together at this place is that the depth on the bar varies but little for a width of 6,000 ft., and there would be very little gain in economy in spacing them farther apart, while there would be a material disadvantage, on the crest of the bar, and so near the sea, in having a wide interval between them. Dredging would be far more difficult, swells would travel farther upstream and pile-work would be more precarious. Here it is best to throw upon the river itself the main burden of the maintenance of its channel. Other things being equal, it is better to have the jetties close together, yet not too close. Mr. Eads made allowance for the effect of tidal flow. The Gulf of Mexico is not strictly a tideless sea. The range between mean high and mean low tide is only about 1.1 ft., but between extreme high and extreme low tide it is 4 or 5 ft. At low water of the river, the ebb has a powerful influence, and even at high tide it increases the maximum discharge by a considerable percentage. It is best, therefore, not to space the jetties the width of the natural pass at 35 ft. depth (that is, about 2,400 ft.), but to allow some latitude for tidal effect. It is possible also that spurs may be necessary, on the inside of the jetties, to prevent undermining—and it is also possible, if the inflow of sand over the low jetties is very great, or if the swell of the sea should cause inconvenience, that inner jetties may be found advisable. If the piers are too far apart, the distance can be easily and cheaply reduced. If they are too close, they may produce incalculable and almost irremediable trouble and harm. For all these good reasons, they have been placed 3,000 ft. apart.

PROJECT FOR DREDGING.

Dredging, it is thought, may have to be performed in three different ways. The total quantity of earth to be removed is estimated at rather more than 22,000,000 cu. yds., divided as follows:

	Cu. yds.
Head of the Passes	1,880,000
Below Pilot Town, to foot of outer bar	4,881,200
Outer bar	15,541,200
Total	22,302,400

Of this quantity, about 6,500,000 cu. yds. are to be taken from the parallel reach.

It is believed that the style of suction dredge used by the Mississippi River Commission may be employed in all this work, with some modifications, perhaps, in construction, to adapt them to the rougher weather and the swells that they will have to encounter. One of them, perhaps, may have something like a sea-going model, for work to be done in the open Gulf, before the jetties are sufficiently advanced to afford any considerable protection. At high water, when the current is strong, in the parallel reach, that is, on the crest of the bar, it is thought that the dredged material may be discharged overboard and carried out to sea. This is the method commonly used with the "G. W. R. Bayley," in South Pass; and it was employed successfully by the "Essayons" and the "McAlester" at Southwest Pass and Pass a l'Outre in 1870 and subsequently. Should a portion of the material lodge in the channel and have to be dredged over again, this would still be a very economical way of handling it. Possibly this method may be used with favorable conditions of tide, even at lower stages.

In case this plan does not succeed, or is too limited in its application, it may be necessary to resort to hopper-barges of suitable model, to be conveyed by tugs to the flats of the wide reaches, where the spoil will be deposited. It is thought that "self-loaders," or regular sea-going dredges, will not be required. The method which it is expected will be most frequently employed, is discharge through pipes. These may be used as auxiliary to the first method, as the distance from the Gulf increases. Their principal use, however, will be at time of slack and low water, in the wide places, when the circumstances will be unusually favorable for their employment. The tests made during the past year on several of the dredges of the Mississippi River Commission show a capacity of 1,000 cu. yds. or more per hour, the material being estimated by direct measurement of the bar whence the earth was taken; the time of the trial being from 24 to 45 hours.

The interesting report by Mr. Lyster, M. Inst. C. E., on the operations of the self-loading dredges "Brancker" and "G. B. Crow," seems to show that the former removed nearly 10,000,000 tons in two years; and that the latter removed more than 4,300,000 tons in one year. The cost of the work done by the "Crow" was 0.61 penny per ton. This includes all charges except interest on capital cost and supervision. The value of these figures is somewhat impaired by the fact that we have no details as to methods of measurement. Mr. Lyster remarks:*

> A comparison between the amount removed, as measured by the capacity of the dredgers, and the deepening of the channel between the buoys, as measured by soundings, shows great variation in the ratio of these two quantities, and in the rate of progress from time to time. But it is obvious that, inasmuch as the soundings were of necessity

*Proceedings of the Institution of Civil Engineers, xxxviii., p. 394.

limited to the dredged channel, they cannot be considered as representative of the actual effect on the whole area affected by the dredging; and any comparison of this sort must therefore of necessity be more or less erroneous.

* * * * * * * *

On the question of the improvement of rivers by dredging rather than by permanent works, the Mersey is a striking instance of the permanent improvement which can be effected with a small expenditure by dredging. For instance, the cost of the whole of the dredging plant on the Mersey bar and shoals, namely, the two large dredgers, has been, say, £120,000; and the average annual expenditure for three years, say, £20,000. Had permanent works been adopted, their cost would no doubt have been enormously in excess of the capital cost above mentioned.

The cost of operating dredges is so complicated with breakages, removals from one place to another, qualities of bottom and conditions of work generally that it is not easy to estimate it correctly. Judging from the trials of the Mississippi dredges, ordinary sand or silt can be removed at a cost of a cent or two a cubic yard, when everything is ready and no accident occurs. The estimate of 4 cts. per cubic yard is thought to be safe, even if a part of the material has to be removed in hopper barges.

It is intended that dredging should be begun at the earliest possible moment—simultaneously with the laying of the foundation-mattress. The latter is to be placed in position before any work on the superstructure of the jetties begins. As the channel to be dredged will be at first in the open sea, it is probable that much time will be lost in the beginning of the work by bad weather. It is deemed possible that it may be best to build the East Jetty before commencing at all on the West Jetty (except laying the mattress) in order to afford protection to the dredge; or at least to keep the east pier well in advance of the west. These details may best be left to the engineer in charge of the construction.

CLOSING CREVASSES.

There are some indispensable precautions to be taken before any considerable progress is made with the jetties. One is the laying of sills across Pass a l'Outre, Cubitt's Gap and The Jump, to prevent their enlarging; another is the closure of the great crevasse near the head of Pass a l'Outre; a third is the closure of the small outlets or bayous which lead from Southwest Pass to the Gulf. The first of these operations is a comparatively easy matter, though not a cheap one. It consists simply in placing a series of brush mattresses, loaded with stone, across the outlets named. The sills are to be 300 ft. wide. They are to be 2 ft. thick. It is thought that they will sink into the mud, so as not to project above the bottom. It is not considered desirable that they should so project, for fear of overfall and vertical eddies. Pass a l'Outre is about 3,600 ft. wide, and has a maximum depth, on the proposed line, of about 40 ft. Cubitt's Gap is 3,240 ft. wide, with a greatest depth of 72 ft. The Jump is 453 ft. wide, and in the deepest place the lead finds 43 ft. The sill across Pass a l'Outre and the closing of the crevasse in the latter branch are subjects of special legislation by Congress. The crevasse occurred in January, 1891. Two or three ineffectual attempts have been made to close it. Parts of the work done in 1897-8 is still in place. The width of the crevasse, in 1896, was 2,230 ft. In 1898 it carried off, according to Mr. Ockerson's measurements, 38% of the total discharge of Pass a l'Outre. It is feared that the complete closure of this gap will be a difficult and expensive work. It is regarded as necessary to the permanent improvement of Southwest Pass, however, to prevent the diminution of volume in the latter which must result from the increased proportion passing down Pass a l'Outre. The sill alone would not be sufficient, for an increase of head above it of a fraction of an inch would give velocity enough over the sill to pass the discharge through the crevasse.

There are a dozen openings in Southwest Pass itself, all of which must be sealed entirely to get the full use of the natural water supply of the channel. These outlets are of various depths and widths, from 100 ft. wide and 40 ft. deep to 2,000 ft. wide and 2 ft. deep. It is intended to close them by superposing tier on tier of mattress, supported, if necessary, by a row of piling. The deposit of silt above the dam and in the interstices between the pieces of brush, will soon make the closure complete.

Tests of Capacity of Portland Cement Barrels, and Weight of Contents by the Boston Transit Commission in 1896.

Howard A. Carson, Chief Engineer.

No. barrels tested; results av'gd.	Brand.	Height bet. heads, ft.	Average Diameter bbl., ft.	Horizontal area, sq.ft.	Capacity barrel bet. heads, cu.ft.	Depression, cement below head, ft.	Volume of depression, cu.ft.	Volume of cement per bbl.—Pkd., c.ft.	L'se, c.ft.	Shaken, c.ft.	Net weight of cement per bbl.; at dumping,—Bfre, lbs.	After lbs.	Weight per cu. ft.—Packd, lbs.	Loose, lbs.	Shaken, lbs.	Sifted, lbs.	W't of barrel, lbs.
6	Giant.....	2.19	1.430	1.605	3.495	0.12	0.171	3.347	4.173	.....	381.0	.....	113.81	91.38	.....	.....	29.0
6	Alsen.....	2.08	1.403	1.546	3.219	0.04	0.059	3.161	4.192	.....	374.2	.....	118.45	89.20	.....	.....	24.3
3	Saylor's.....	2.07	1.412	1.571	3.249	0.07	0.096	3.152	4.052	.....	387.0	.....	122.75	94.24	.....	.....	22.7
5	Dyckerhoff...	2.01	1.407	1.554	3.123	0.07	0.093	3.031	3.989	3.522	373.2	371.4	123.16	93.18	105.54	.....	25.6
1	Fiske Lion*..	2.13	1.38	1.496	3.186	0.03	0.039	3.147	4.270	3.695	378.0	378.0	120.11	88.52	102.29	.....	22
5	Atlas.....	2.12	1.437	1.622	3.446	0.17	0.235	3.211	3.754	3.432	377.4	376.9	117.54	100.49	109.45	90.6	21.1
5	Aalborg†.....	2.01	1.455	1.662	3.327	0.10	0.148	3.206	4.058	3.598	370.7	370.2	115.71	91.40	102.94	80.3	23.3
	Final averages	2.09	1.418	1.579	3.292	0.09	0.120	3.179	4.070	3.562[2]	377.4	374.1[2]	118.79	92.63	105.06[2]	85.4[2]	24.0

*(Hanover). †Denmark. [1]Shaken longer than others. [2]Partial averages. To be compared only with like brands.
[3]Box rocked over bar. Note.—Paper weighs about 1 lb.

ALLOWANCES FOR CONTINGENCIES.

It is believed that dredging alone will suffice to make and maintain the channel at the Head of the Passes. It is the opinion of some experienced engineers, however, familiar with the local conditions, that it may be necessary to do more than this—to build a deflecting dike, to turn a portion of the current down the channel chosen for deepening. If so, the work would not be expensive.

In the estimate submitted by the board of $6,000,000, there is an item of nearly $1,500,000 for contingencies—about 32% of the sum of the various separate estimates. This is intended to cover not only unforeseen contingencies, but such as can be foreseen and cannot be estimated—and others which are regarded as possibilities, though not probabilities. The unforeseen contingencies are the absolutely unexpected things that happen more or less to every engineer in the course of his experience. They become less and less as the engineer becomes wiser. Contingencies which may be foreseen but cannot be estimated are breakages of machinery, washouts by currents, damage by storms, miscalculations through simple error, imperfect data or want of knowledge of local conditions, extraordinary sinkage of work, higher prices of labor and materials, interruptions by weather or pestilence, failure of contractors and the like.

Works which may possibly be needed are the laying of temporary tracks where the method of depositing the concrete blocks from barges may not be found practicable or economical—permeable pile-dikes to contract the waterway through the jetties and promote deposit of silt in the wide places—cribs or short spurs in the parallel reach, or near the sea ends of the jetties, to prevent damage by racing waves or undermining by currents—training dikes at the Head of the Passes, etc. Possibly inner jetties may be required. It may also be advisable to extend the upper end of the West Jetty so as to start at Stake Island. The location has been made only on paper, and when tried on the ground it may have to be modified. The method of construction may have to be changed in places, and concrete in bags, or riprap substituted occasionally for concrete in blocks.

Of course, in a river of so unstable a bed, conditions at the time of execution are not going to be the same as those existing when the survey was made. They may be more or less favorable, or, what is more probable, the average may be nearly the same. The channel will not be in the same place in 1901 as in 1898, but there will be a channel, and very probably of about the same dimensions.

WEIGHTS OF PORTLAND CEMENT AND CAPACITY OF CEMENT BARRELS.

By Sanford E. Thompson,* Assoc. M. Am. Soc. C. E.

The table given herewith is compiled from tests made by the Boston Transit Commission in 1896 in preparation for the subway work. The figures are taken directly from the original note-book of the Commission, through the courtesy of Mr. Howard A. Carson, Chief Engineer, and the writer has endeavored to place these notes in such form that they may be of value for reference. Accompanying the table, also, are given a number of ratios deduced from the averages of the various columns.

While the matter given covers only a comparatively few brands of cement, no apology, it is believed, will be necessary for its presentation. There is in print a large amount of matter relating to cement and concrete, but records of careful experiments outside of the region of tests of strength are few.

In making the tests, the barrels of cement of the various brands were selected at random and the record of each barrel made independently. Each barrel was first weighed, then one of the heads was removed and a measurement taken of the depression of the cement below the head, so as to obtain the actual volume of the cement independent of the capacity of the barrel. The cement was then dumped into a box, in many of the tests again weighed, and in all cases its exact volume in the box measured. The cubic capacity of the barrel was obtained by careful measurements of a number of diameters, and a measurement of the distance between the insides of the heads. In some cases the volume of the cement shaken, that is, after rocking the box over a bar, was found, and in two of the brands the weight per cubic foot of the cement after it had been sifted was obtained. From these measurements calculations were made which are recorded below.

The ratios following are derived directly from the final averages in the table, except where these averages are only partial. In such cases both numerator and denominator of the ratio are the averages of like brands. For example, in the ratio of "Weight packed to weight sifted" only Atlas and Aalborg cements are used in each term, because these are the only cements in which the weight sifted was recorded. Ratios are as follows:

Ratio	Volume of packed cement to capacity of barrel between heads	$\frac{3.179}{3.292}$	= 0.966
	Volume packed to volume loose..	$\frac{3.179}{4.070}$	= 0.781
	Volume packed to volume shaken.	$\frac{3.149}{3.562}$	= 0.884
	Volume loose to volume shaken..	$\frac{4.018}{3.562}$	= 1.128
	Net weight before dumping to net weight after dumping.....	$\frac{374.8}{374.1}$	= 1.002
	Weight packed to weight loose ...	$\frac{118.79}{92.63}$	= 1.282
	Weight packed to weight shaken.	$\frac{119.13}{105.06}$	= 1.134
	Weight packed to weight sifted...	$\frac{116.62}{85.40}$	= 1.366

The column in the table headed "Capacity of barrel between heads" is the actual net volume of the empty barrel, and it is this volume which would naturally be used in most cases where concrete is proportioned by so many parts sand and broken stone, or gravel, to one part of cement. The average given, 3.292 cu. ft., is slightly above the average volume of a foreign Portland cement barrel, but below the volume of the barrels used by the American Portland cement manufacturers. The barrels used for the American natural cements are still larger than those used for the Portland.

*Newton Highlands, Mass.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page ▼*XI-XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

In our issue of July 5 last, we discussed the value (or lack of value) of high speed in torpedo vessels, and pointed out that the present craze for high speed in this class of craft is unwarranted by any practical considerations of its actual usefulness in warfare. A recent issue of the "Proceedings of the U. S. Naval Institute" contains a number of papers by naval officers in which similar ideas are expressed regarding the attempts to obtain excessively high speed at the sacrifice of stanchness and reliability. One of the papers in the number, by Lieut. A. P. Niblack, was abstracted in our issue of Nov. 23, 1899, p. 343, and was notable for its emphatic condemnation of the craze for high speed and its plain showing that such speeds add nothing to the offensive powers of these vessels. In another paper in this magazine, Lieut. R. H. Jackson urges that 28 knots is sufficient speed for vessels of the "destroyer" class, "and gives a surer indication of the value of the boat than a delusive 32 knots with bottled up steam over the measured mile." For torpedo-boats proper he says: "20 knots is thought to be a good sustained speed for an all-night run in moderate weather. This would give a 25-knot speed for the dash to escape after the attack."

Commander Drake, U. S. N., says:

> The impossible has been attempted with torpedo-boats by all nationalities, with the result that the object sought has not been accomplished beyond a doubt, either in practice trials at sea or in action. In my opinion, the failures being due to the limited displacement for the so-called sea-going class, high speed required (which, by the way, is never maintained with satisfaction under cruising conditons calling for emergency action) consequently light structural strength of hull and engines.

Finally, Naval Constructor P. F. Ruhm gives a graphic illustration of the sort of frail structure the modern high-speed torpedo vessel has become, and we quote his remarks as follows:

> In order to satisfy the desire for great speed in torpedo-boats and torpedo-boat destroyers, the weights of machinery and hull must be reduced to a minimum, thus increasing the possibility of serious accident to both. The extreme lightness of the scantlings of the hull increases the effect of the tendency of all parts to vibrate, and such extreme vibration must undoubtedly affect not only the strength of the material but the nervous systems of those on board. The reducing of the speed requirements by two knots and the increasing of the weights of hull and machinery accordingly would give a really more efficient vessel, less liable to accident, and more capable of standing whatever weather may be encountered, or whatever handling around docks, etc., may be necessary in the course of the general duties of the vessel.
>
> In the case of the trial trip of one of the fast destroyers the vibration of the stern plating was such that a piece of one of the plates in the neighborhood of the propeller by constant buckling finally broke and a three-cornered piece was torn out by the rush of the water, the stern compartment rapidly filling. On the same vessel, in trying to get away from the dock, the stem was gently touched against the adjacent wharf, the result being that the stem was absolutely twisted out of shape and part of it required replacing. Were the scantlings of this boat consistent with the duty required, accidents of this sort would have no serious results.

The idea that bacteria, living in water or other liquids, might possibly be killed by powerful squeezing, has doubtless occurred to many persons. Actual tests to determine the feasibility of this scheme were carried out last year by Mr. B. H. Hite, Chemist of the West Virginia Agricultural Experiment Station. Of course, it is known that moderate changes of pressure, such as occur in water passing through a pumping engine for instance, are survived by bacteria with little or no injury. It does not follow, however, that higher pressures might not prove fatal to these organisms. The human body, for example, endures with little difficulty an increase in atmospheric pressure of 10 to 20 lbs. As the pressure increases injury begins, and a limit is soon reached beyond which one cannot go and survive. Similarly fish and plants in the ocean are known to be sensitive to the pressure at great depths.

To investigate the effect of pressure on bacteria, an apparatus was devised which is described on another page of this issue, and which is remarkable for having produced what is probably the greatest hydrostatic pressure ever reached, over 450,000 lbs. per sq. in. The particular object of these experiments was to determine whether the bacteria in milk might not be killed by hydrostatic pressure, so that it would keep a longer time without souring. Moderate pressures were first tried, but appeared to have no effect. The pressures were then increased and notable results were obtained. Milk subjected to pressures of 70 to 100 tons kept from 24 to 60 hours longer without souring than untreated milk. The degree to which the keeping qualities of the milk were improved appeared to depend as much on the time for which the pressure was maintained as upon the actual pressure reached. Pressures of 90 tons per sq. in. maintained for an hour delayed the souring of milk from four to six days. Complete sterilization of the milk, however, was in no case effected even at the highest pressures, and the milk in many cases acquired peculiar tastes and odors on keeping, indicating that certain species of bacteria were killed while others were not.

Tests were also made with samples of milk inoculated with disease germs, in the hope that these germs might prove more susceptible to pressure. In the first of these experiments the tube burst, the typhoid-inoculated milk was scattered all over the room and one of the staff of experimenters was soon after stricken with typhoid. The experiments were completed, nevertheless, at a later date; but the microscope showed that some of the germs always survived the treatment.

The net results of these experiments was, on the whole, therefore, not encouraging as to the prospects of a practical antiseptic process being developed on these lines. It was, however, found that milk, meat and similar perishable articles could be made to keep considerably longer without spoiling as a result of the treatment; so there still remains a possibility that some process of practical value may be developed in this direction.

The bill drafted by Secretary of the Treasury Lyman J. Gage for the establishment of a National Standardizing Bureau was commented upon in our issue of May 31. At the same time we took occasion to draw the attention of engineers to the importance and desirability of such an institution in this country, both from the standpoint of pure science and that of engineering and commerce. The bill above referred to was passed over to the Committee on Coinage, Weights and Measures, which reported unanimously in favor of its passage. In the hurry and confusion of the last few days of the session, however, it was impossible to get the matter before the House.

At a recent meeting of the American Institute of Electrical Engineers, a paper describing the Imperial Physico-Technical Institution at Charlottenburg, Germany, was submitted by Prof. H. S. Carhart, of the University of Michigan, who has recently spent some time there in scientific investigation. This institution, which has cost approximately $1,000,000 and on which about $75,000 per annum is spent for maintenance, holds a pre-eminent position in regard to all matters of exact physical measurements and determinations. Not only has it been of great service to German scientists and manufacturers, but it has been appealed to by the different departments of our own Government, and its determinations are sought as final authority by laboratories all over the world. In addition to standardizing it offers unexcelled facilities for original research. Realizing the importance of such an institution, the Governments of both England and France have set about to establish similar ones, which, as Prof. Carhart remarked, is the sincerest form of flattery.

Whether the United States shall possess a similar institution at an early day will be determined by the fate of the bill already referred to, which will be brought up at the next session of Congress. The electrical engineers, following the reading of Prof. Carhart's paper, determined to take measures both as a society and individually to urge the passage of the bill. If other engineering and technical societies take similar action there should be a good prospect of its passage.

A CONSOLIDATED INDEX TO ENGINEERING NEWS.

We have an announcement to make which we are sure will be of much interest to our subscribers, and especially to that increasingly large number who preserve and bind their copies of Engineering News. It is that we have near completion an index to Engineering News for the ten-year period from 1890 to 1899, inclusive. The presswork on the book is now in progress, and the complete work will be ready during the coming month.

The need of such an index has long been evident to us. Not a day passes but numerous letters come to this office inquiring what we have published in past volumes on this or that or the other subject, on which the writers desire information. These are but an indication, we are sure, of the many who desire similar information and who laboriously search for it through the indexes of the separate volumes or give up the task altogether, because of the labor involved.

The need for some more convenient means of reference to matter published in past volumes became so pressing in this office some years ago that work was begun upon a consolidated card index to Engineering News. This has been added to year by year, until at the end of last year it was complete for ten years 1890 to 1899 inclusive. We then felt that it was time our readers were given the benefit of this for use in referring to their own files; and work was at once begun editing the card index and putting it in shape for publication in book form. The task has been so considerable, however, that not until the completion of the first half of the year was the manuscript ready for the printer.

A better idea of what the work is and what its field of usefulness will be can be given by a sample page than by extended description, and we accordingly present one herewith. The completed book will contain about 350 such pages, and the total number of references (making fair estimates for the cases where many references occur under one heading and where cross references occur) may be set at about 25,000.

To bring the book within reasonable limits of size and also to avoid giving references to articles of too little importance to be worth looking up,

the notes of current news, such as are published on the first page of each issue, are omitted from the index.* The occasional searcher who desires to refer to information given in these notes, for historical researches or other purposes, will still have to look through the separate volume indexes. Practically all the other matter in the 20 volumes, however, is covered by the new consolidated index.

A word as to the typographical arrangement and mode of referencing adopted may not be without interest. One important feature which we think will be found very convenient is the reference to volumes by years and not by volume numbers written in Roman numerals according to the ordinary fashion.

If John Smith, for example, looks up a certain article in an index and finds it was printed in vol. xxxviii, p. 112, the chances are a hundred to one that he will not know in what year "vol. xxxviii" was printed. In our index, however, the date is at once given, thus: "97, ii—112." The "97" indicates the year 1897; the "ii" shows that the reference occurs in the second volume of that year; and "112" is the page number. Often the knowledge of the year in which the article was printed will enable one to choose which one of several references to consult. One article is seen at a glance to be too early in date to be a complete description, or the searcher may have in mind the approximate date of an article which he desires.

It will be seen from the sample page that in many cases a few words are added to give some idea of the scope of an article. Of course, not much was possible in this direction without expanding the book to an impossible size. Illustrated articles are denoted by an asterisk (*) and articles accompanied by an inset sheet of engravings by a dagger (†). These marks will be found very helpful in selecting the most important articles on a subject where a large number of references are given under one head.

Many of our old subscribers will object, we presume, because the index does not cover years previous to 1890. It was felt, however, that "the greatest good to the largest number" would be attained by stopping at the 10-year limit. To have included earlier volumes would have added to the cost of the book, delayed still longer its publication and made more difficult and expensive the task of making up complete sets of volumes for the years which the index covers. Besides this, two indexes to these earlier volumes have already been published—one by Mr. F. E. Galloupe, and the other, the "General Index to Engineering Literature from 1884 to 1891," edited by Prof. J. B. Johnson and published by the Association of Engineering Societies. The latter volume, it may be noted, carried its references to Engineering News back of 1884, and was made to include all important articles published in the paper from its establishment in 1874.

The publication of this new consolidated index is in line with the definite purpose of those in charge of Engineering News to make it of the greatest practical usefulness to American engineers—and we use that latter term in a broad sense. In fulfilment of this purpose it is our aim to make this journal at once an engineering newspaper and a technical record of engineering work, which shall be of permanent value for consultation. Many of our readers, we know, fully appreciate the latter use of the paper. Others adopt the habit, which has grown up since technical and trade journals became so numerous, of glancing over the pages of each issue for articles in their especial line, cutting out any article which they deem worth preserving and consigning the rest to the waste-basket. We want to urge upon this class of our readers that they are not getting all the benefit they might from their subscription to Engineering News. A very large proportion of the articles published in this journal are selected with especial reference to their value as a permanent record, for consultation by the working engineer. The extent of this matter and the breadth of the field which it covers far exceed that of any other American engineering publication. In connection with the new index, these twenty volumes of Engineering News for the decade ending in January last form, in fact, a complete encyclopedia of engineering, and a working engineering library more up to date than the text books.

We do not take space to say this here from any desire to praise our own work, and it is a fact which we are glad to acknowledge here, that Engineering News belongs to and is the work of the American engineering profession even more than it belongs to and is the work of its owners and conductors. The steady development of this journal during the past decade has been made possible by the able and generous support of its subscribers and advertisers and contributors. Our task it has been so to guide and direct their work that the outcome might be of the greatest benefit to the profession.

What we wish to do, therefore, is not by any means to "'blow our own horn," but to call the attention of our readers to the value and advantage of preserving their copies of Engineering News If the present book index is welcomed by our readers as we expect, a similar index can confidently be relied upon for the volumes from 1900 onward, and very likely at a considerably earlier date than 1910.

From one point of view, it makes no difference to us what disposition our readers make of their copies of Engineering News. On the other hand, we are interested that our readers shall obtain the greatest possible benefit from their subscription to this journal, and that it shall fill the largest possible field of usefulness. It is to that end that we are advising the young engineer to preserve his volumes of the paper, and it is to that end that we have undertaken the task of making these volumes most useful to their owners.

40 CAISSONS.

Caissons: (Continued.)
Harlem River bridge, Seventh Ave. By W. G. Triest. 93, ii-*198.
Improvement in pneumatic caissons. 94, ii-*108.
Invention in 1728. 95, i-47.
Jacksonville, Florida, bridge. 92, ii-*604.
Lengthening stone dock, Livourne, France. 90, i-225.
London Tower bridge. 94, i-†43.
Manhattan Life building, New York. 93, ii-*458.
Memphis bridge, Miss. River. 92, i-470; 93, ii-*509.
Mercantile building, New York. 97, ii-*38.
Omaha drawbridge, Design and sinking. 93, ii-*410.
Quindaro bridge, Kansas City, Mo. 91, i-†321.
Rolling caissons for closing entrance to tidal lock, Bruges canal. 99, ii-*300.
Sea wall construction, San Francisco, Cal. 90, ii-*96.
Timber:
East River bridge. 97, i-†331.
Pneumatic cylindrical, Foundation of residence. 98, ii-*363.
Calcium carbide. (See Acetylene.)
Calculating machine for computing pay rolls. 97, ii-*123.
Calculus, Rational presentation of. 93, ii-332.
Calipers, Cast iron pipe. 93, i-585.
Calorimeters:
Barrus Universal. By G. H. Barrus. 90, i-*520.
Carpenter steam. By R. C. Carpenter. 96, i-*351.
Mahler, Experiments at Ohio State University. By N. W. Lord and F. Haas. 97, i-184, 188.
Measurements to test accuracy. 94, ii-484.
Throttling, Reliability of. By J. E. Denton. 95, ii-374, 400.
Cameras:
Magazine plate. 98, i-*311.
Revolving, in surveying work. 99, ii-*126.
Canadian notes. 92, ii-424; 97, ii-139.
Canadian Society of Civil Engineers:
Close corporation. 96, i-288; 96, ii-120, 123.
(See also, Civil engineering, Close profession.)
Code of ethics. 96, i-102.
Constitution, New. 93, i-108.
Convention at Montreal. 97, i-64.
Canaigre cultivation in Mexico. 96, ii-422.
Canal boats:
Electric propulsion:
Bourgogne canal, France. 93, ii-425; 95, i-129.
Burgundy canal. 95, ii-64.
Erie canal, Notes. 93, i-52, 570; 93, ii-145, 405, 435; 94, i-21; 95, i-297; 95, ii-65, 289.
Ohio, Resolution before Legislature. 94, i-129; 94, ii-496.
(See also Boats, Towing device.)
History of propulsion. By W. H. Bailey. 90, ii-189.
Steel:
Cleveland to New York. By Lewis Nixon. 96, ii-*332.
Lorain, Ohio, to Brooklyn, Notes. 95, ii-113, 145.
Twin-screw propellers, Ireland. 94, ii-392.
Canal locks:
Brief discussion. By Henry Goldmark. 99, ii-326.
Cascades canal, Columbia River, Details of gates. 97, ii-†262, †283.
Concrete:
Coosa River, Alabama. By Charles Firth. 96, i-†116.
Illinois & Mississippi canal. 95, i-†98, *101.
Rough River, Kentucky. 95, ii-145.
Osage River, Missouri. By F. B. Maltby. 98, i-†276.

(*) denotes an illustrated article. (†) denotes an inset sheet.

SAMPLE PAGE OF INDEX TO ENGINEERING NEWS, 1890-1899.

*In a few cases, where the connected history of an enterprise could be gleaned from these weekly items, they have been preserved in the new index and designated as "Notes," to distinguish them from the more extended technical articles.

LETTERS TO THE EDITOR.

Making Foundations in Soft Ground Without Piling.

Sir: I notice in your issue of Sept. 27, an article concerning "A Novel French Method of Making Foundations in Soft Ground." A similar method to that of Messrs. Dulac & Ducloux has been been employed in Europe for many years in the foundations for light structures in soils that were soft, and where timber piling was either exposed to rot or was too expensive.

In 1865 I saw the following method applied in making the foundations for the walls of a large building in Dresden, and about the same time my Professor of Architecture, Professor Heyl, mentioned this method in his lectures as one of the means for preparing foundations for buildings: An ordinary pile of hard timber, conical shaped with smooth exterior surface, was driven into the soft ground and then slowly extracted. Into the hole thus formed, ashes, sand or gravel were poured. After the necessary number of these columns were formed, a layer of such material was placed upon the ground, a rammer passed over it and the material thoroughly rammed to the satisfaction of the architect. The object was precisely the same as in the foundations you mention, namely, compacting the soil. The older method seems to have the advantage that the compacting is not done until after all the holes have been filled, and, thus, causing a more uniform composition.

Of course, these methods can only be applied where the weight of the building is not great. When the foundations thus treated are extensive in area, the devices of Messrs. Dulac & Ducloux undoubtedly have advantages. The older method may be used by anyone, with apparatus easily and cheaply made. Yours truly, Rudolph Hering.

100 William St., New York, Sept. 28, 1900.

The Move for Municipal Ownership of Water-Works at San Francisco, Cal.

Sir: There seems to be quite a determined effort on the part of many citizens to secure municipal ownership of water-works here. The board of supervisors is trying to carry out the provisions of the new city charter in relation to the acquirement of public utilities. Accordingly, it passed a resolution (No. 207) on March 19, 1900, the body of which was as follows:

Resolved, That the Spring Valley Water Co. is hereby requested to offer for sale to the city and county of San Francisco, on or before June 1, 1900, at the lowest possible cost, all of its property now used or capable of being used for supplying water to the inhabitants of the city and county of San Francisco.

The Spring Valley Water Co. is also requested to make a detailed statement of such property, with a full statement of the use to which the various parts of such properties are put, together with a detailed statement of the cost of the construction of its entire water system.

The Spring Valley Water Co. is also requested to bear in mind that any over-valuation of its water system will compel the people of San Francisco to look elsewhere for their water supply, and the withdrawing of San Francisco as a market for the sale of the company's water will reduce the value of the company's lands to what they are worth for agricultural purposes merely.

Such an offer of sale must contemplate the placing in escrow of a deed to the entire system, dependent for delivery upon the acceptance of the offer by the people of San Francisco, voting at a special election to be held in the year 1901.

The board, on March 26, 1900, passed a second resolution (No. 257), calling upon other corporations and persons for proposals to sell water-works and water rights to the city, stating that the present daily supply is estimated at 25,000,000 gallons, and that the future supply contemplated "may be taken as two or three times the existing consumption."

An answer to the first resolution was filed by the Spring Valley Water Co. on May 31, in which some technical objections are made to the regularity of the board's proceedings in the matter and to certain matters in the resolution, but in which answer it states that in "proper proceedings" the Spring Valley Water Co. would be willing to sell its property to the city at a valuation to be fixed by three arbitrators, one to be named by the company, one by the city, the third to be named by these two. In this answer the company does not place a valuation upon its property nor give any inventory of it.

In response to the resolution the following propositions have been submitted: -

April 5, by M. C. Taylor, San Francisco.—Offers to sell his water right of 10,000 miners inches, or 175,000,000 gallons per day, to the flow of the Yuba River at "moderate figures." Mr. Taylor claims that $12,000,000 will cover the expense of constructing the works necessary to deliver 60,000,000 gallons per day into San Francisco from this source. He does not make any definite proposition. He states that there is abundant water of proper quality in his proposed source of supply to furnish 175,000,000 gallons per day.

April 14, by Jersey City Water Supply Co., Brooklyn, N. Y.—Offers to deliver 100,000,000 gallons per day at a city reservoir (site to be mutually agreed upon) for $35 per 1,000,000 gallons. Contract to be for at least 100,000,000 gallons daily for 40 years; or will sell the works to the city upon their completion for $25,000,000 in city 40-year 4% bonds. Source of supply not stated.

April 24, Lake Tahoe and San Francisco Water-Works.—(See Eng. News, May 3, 1900, p. 281.)

May 5, by Jay F. Russell, San Francisco.—Source of supply, American River; diversion point, 1,050 ft. above sea level, by two 48-in. steel pipe lines, 118 miles long; fall 6 ft. per mile, to deliver 60,000,000 gallons per day 300 ft. above sea level at San Francisco. Mr. Russell offers to sell his 820 acres of land (presumably including his water rights) at proposed point of diversion for $100,000. He submits an estimate of $4,104,379 for constructing the necessary works, including diversion dam and $100,000 for his property. He does not offer to do the construction work, however. He specifies No. 14 steel for the pipes, which is, of course, too light.

May 21, by D. E. Gish & Co., San Jose, Cal.—Offers to deliver 40,000,000 gallons per day at San Francisco city limits for $5,000,000, or 50,000,00 gallons per day for $5,500,000, or 60,000,000 gallons per day for $6,000,000, in two pipe lines, from artesian wells in Santa Clara county; elevation of point of delivery not stated (presumably not much above sea level).

May 21, Marysville & Nevada Power & Water Co., Smartsville, Yuba Co., Cal.—Offers to sell water rights to 10,000 miners inches of the flow of the North Yuba River at a point 1,800 ft. above sea level. No price stated, but asks for investigation of its proposition and titles to the water, etc.

May 31, Eel River & Russian River Water-Works, San Francisco.—Offers to deliver at city 50,000,000 gallons per day 300 ft. above sea level for $18,500,000. Source of supply, Eel River by tunnel to Russian River. From Russian River by canal and pipe line to San Francisco.

June 1, by Standard Electric Co, of California. San Francisco, Cal.—Calls attention to possibility of supplying city with water from the waste water from its power house in Amador Co.; states that its waste water (after being used for power) is not less than 75,000,000 galons per day. Makes no definite proposition at this time, but intimates that it will after getting additional data.

The above are the only propositions which have been submitted under the second resolution.

About Aug. 1, three field engineering parties were sent into the field to make surveys for water systems for supplying the city. The work is under the general direction of City Engineer Grunsky. One party is examining the Lake Tahoe source, one the Yuba River, and one is making surveys for a route for pipe line into the city from these proposed sources of supply. It is hoped to make some preliminary reports upon the subjects by Jan. 1, but Mr. Grunsky does not deem it possible to have definite and complete results by that time, but a further time for surveys and reports will be absolutely necessary before any definite proposition can be submitted. In addition to the three field parties, the department has a man employed looking up water titles. On the whole, it appears to me that the engineering department is determined to go ahead with the deliberation and care necessary to a work of such great difficulty and importance and that it will refuse to be hurried into making any final report without the necessary data and investigation.

There is much prejudice against the Spring Valley Water Co. among people here, and there will be much opposition to buying its works. Its works have grown with the growth of the city and are not generally regarded as guaranteeing sufficient water for the expected increased size of the city in the near future. On the other hand, the Spring Valley Water Co. claims that its works are susceptible of economical additions to meet increased demands for water. You will note the implied threat in the last part of resolution No. 207 in regard to possible withdrawing of San Francisco as a market for the Spring Valley water. From this and from other things, it would appear that it is not likely that that company will be able to sell its plant to the city for more than one equally good for the purpose could be constructed. A good many people with whom I have talked are prejudiced against stored water, and would prefer to get water from such mountain sources as the Yuba River or Lake Tahoe, even at greater cost. From the best information I can get, however, I think the quality of Spring Valley water is generally pretty good. Civil Engineer.

San Francisco, Cal., Sept. 8, 1900.

Notes and Queries.

Mr. E. A. Williams, Mechanical Superintendent of the Minneapolis, St. Paul & Sault Ste. Marie Ry., calls our attention to a typographical error in a table printed in our issue of Sept. 20, p. 190, giving comparative dimensions of three recent heavy locomotives. The diameter of the flues of the new engine No. 600 for the above-named road is 2 ins. instead of 2¼ ins.

In reply to W. S., who inquired the meaning of the term "watch tackle," a Chicago correspondent sends the following:

A "watch tackle," or "handy billy," is a two-sheave tackle, used by the watch on board ship to handle yard arms and perform other duties in which a greater number of men would ordinarily be required. The watch puts the "watch tackle" on as a luff on the line which the crew would otherwise pull direct.

Our attention has been called by Mr. Walter H. Sawyer, 80 Congress St., Boston, Mass., to an error in the diagram Fig. 3, accompanying the article on "Experiments on the Flow of Water Over Dams," in our issue of Sept. 27, 1900. The abscissas should have been discharge in cubic feet per second and the ordinates, head in inches, instead of the reverse.

A LOCOMOTIVE WITH "HELPING CYLINDERS" AT THE PARIS EXPOSITION.

Among the locomotives in the German section of the railway exhibits at Vincennes is one shown by the firm of Krauss & Co., of Munich, which easily ranks first in novelty among the many locomotives there shown. The general design of this engine is shown by the accompanying illustrations, reproduced from our Paris contemporary "Le Genie Civil," of Aug. 11, 1900. As will be seen from Fig. 1, this locomotive is provided with a pair of small auxiliary driving wheels located between the truck wheels, which, remaining normally clear of the rails, can be lowered in case of necessity so as to provide additional tractive power for climbing steep grades or starting heavy trains, and thus allow the main driving mechanism to be kept down to dimensions sufficient only to maintain speed upon the more level portions of the line. Another peculiarity of the design is that reciprocating counterbalances are provided to balance the pistons and other reciprocating parts. The location of these counterbalances is shown to the rear of the main drivers in Fig. 1. Except in the particulars just mentioned, the locomotive is a normally-appearing inside cylinder engine which would excite no particular comment among locomotives of European design, although it would look somewhat strange in a group of American passenger engines.

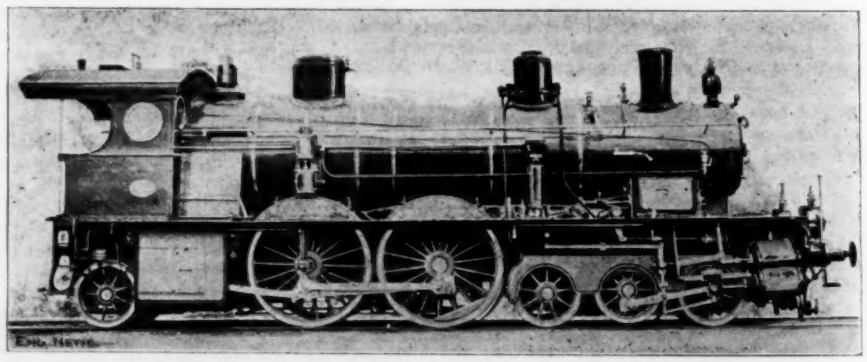


FIG. 1.—COMPOUND EXPRESS LOCOMOTIVE, WITH AUXILIARY DRIVING WHEELS AND PISTON COUNTERBALANCE; PARIS EXPOSITION, 1900.
Krauss & Co., Munich, Germany, Builders.

The following table shows the principal dimensions of this locomotive:

Gage of truck	4.69 ft.
Boilers:	
Steam pressure	210 lbs.
Diameter of barrel (inside)	4.79 ft.
Tubes, number	238
" diameter, exterior	2.04 ins.
" length between tube sheets	16.7 ft.
Heating surface, firebox	127 sq. ft.
Heating surface, tubes	2,055 "
Driving wheels, number	6
Main, diameter	6.13 ft.
Auxiliary, diameter	3.28 "
Truck wheels, diameter	3.28 "

Cylinders:	
Main, high-pressure	25.98 x 17.32 ins.
Main, low-pressure	25.98 x 25.50 "
Auxiliary, both	15.74 x 10.28 "
Weight:	
On main drivers	28.2 tons.
On six drivers	41.6 "
Total weight, loaded	68.0 "

It will be observed that the boiler is placed rather high, 8.65 ft. from the rail to the axis of the boiler, and that it increases in diameter at the rear to form a sort of incipient "wagon top." The fire-box is placed over the frames and has a width of 1.8 m. (5.9 ft.) and a length of 1.61 m. (5.28 ft.). The main cylinders are set at an angle of 7° with the horizontal. The valves are plain slide valves operated by Walschaert gear actuated from the connecting rod. The reversal of the valve gear is accomplished by means of a horizontal shaft, which actuates, by means of bevel gears, a vertical screw, the movable nut of which is connected to the reversing mechanism. The location and character of this device is shown at A, Fig. 2.

The location and general nature of the piston counterbalance is also shown by Fig. 2. It consists simply of a heavy cross-head, or weight, sliding between guides, located at the rear of the main drivers and in line with the piston rods. This cross-head arrangement on each side is connected to the drivers on that side by special connecting rods, and the crank is located nearly 180° from the inside crank on the other side of the wheel. Thus the counterbalance's motion is in the opposite direction to that of the piston. The arrangement, it will be seen, works in very well, with an inside cylinder construction, but we imagine that few American engineers will be favorably enough impressed with its practical value to regard it as more than an interesting curiosity. Our contemporary gives no data regarding its operation or the practical advantages claimed for it.

Turning now to the auxiliary driving wheels, it will be seen from Figs. 1 and 2 that they are operated by separate outside cylinders inclined, like the main cylinders, at an angle of 7° from the horizontal. The valve motion employed is a modified Joy. Steam is delivered by a pipe which emerges from the front end of the boiler and passes downward and forward through the smoke-box to the steam chests. The exhaust passes by a similar pipe through the smoke-box to the exhaust nozzle. Steam admission is controlled by the shaft B, Fig. 2, passing from the cab to a bell crank arrangement, which actuates the throttle valve located just where the steam pipe leaves the boiler. This arrangement is so connected with the mechanism which raises and lowers the driving wheels that steam cannot be admitted to the cylinders until the wheels have a full bearing on the rails.

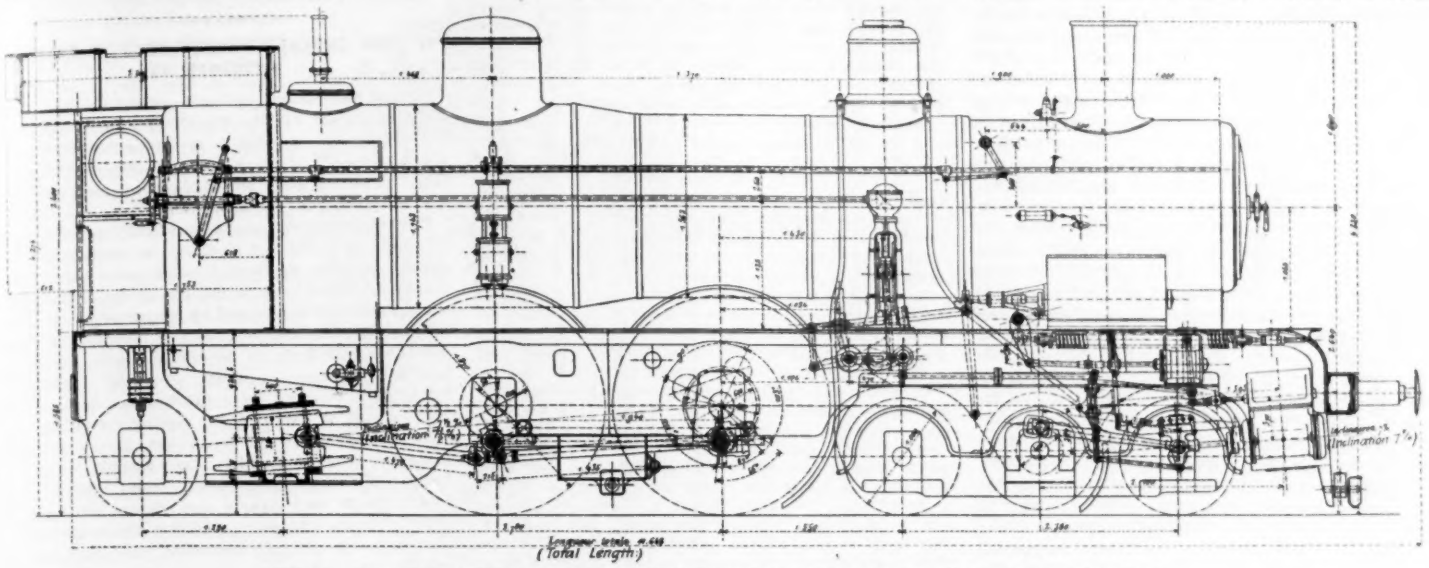


FIG. 2.—SIDE ELEVATION OF COMPOUND EXPRESS LOCOMOTIVE AT PARIS EXPOSITION.

The mechanism for raising and lowering the auxiliary driving wheels is indicated by Fig. 3. By means of a special valve, steam at boiler pressure is admitted to the forward end of the cylinders a. This forces back the piston rods, which, by means of the two crank arms and the shaft b, presses down the shafts c and the driving axle against which they bear. By exhausting the steam from the cylinders a, the springs shown in diagram raise the wheels to their normal position of 30 mm. (1.18 ins.) clear of the rails. When the driving wheels are raised the forward truck wheels carry the total weight, but they are, of course, relieved of part of this weight when the driving wheels are pressed to a bearing. The relative distribution of the weight in French tons under the two conditions is given as follows:

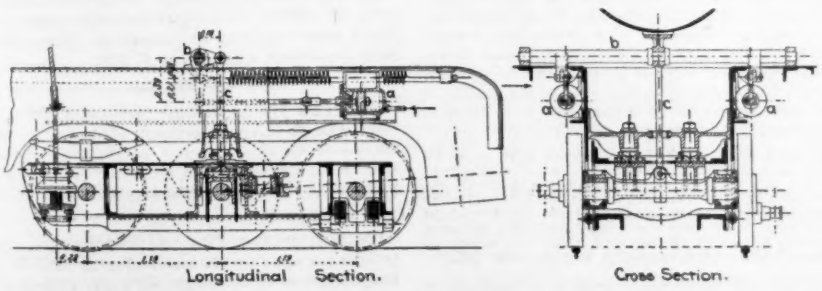


FIG. 3.—MECHANISM FOR PLACING AUXILIARY DRIVERS IN ACTION, COMPOUND EXPRESS LOCOMOTIVE, AT PARIS EXPOSITION.

	Driving wheels raised.	Driving wheels bearing.
Forward truck wheels	14.8	8.1
Driving wheels	0	13.4
Rear truck wheels	10.9	4.2
Total	25.7	25.7

The weight on the main drivers is not altered by throwing the auxiliary driving wheels into operation.

Another type of "helping cylinder" locomotive built for the Bavarian railways by the same works was illustrated and described in our issue of June 10, 1897. The present machine, however, has a different arrangement for throwing weight onto the auxiliary drivers, and its reciprocating counterbalances make it on the whole the biggest curiosity in locomotive design that has been seen in a long time.

EXPERIMENTS IN BOAT TRACTION by means of electric locomotives were recently made on behalf of the Prussian Government by Siemens & Halske, of Berlin. The following account is abstracted from the report of the same given by U. S. Consul-General Richard Guenther, of Frankfort:

The scene of operations was a short length of the Finow Canal, which forms a portion of the waterway between Berlin and Stettin and is traversed every year by about 25,000 to 26,000 boats each way. The craft used are in the main barges, some 132 ft. long by 15 ft. 6 ins. beam, carrying 150 to 175 tons. There are also a few steam barges employed, which carry about 150 tons and can tow a second barge. The section of canal used for the experiments was selected owing to its physical difficulties, presenting as it does several curves, in one of which with only 328 ft. radius the waterway is spanned by a railway bridge. The line laid down for the towing engine was of 3.28 ft. gage, the outer rail weighing 18.2 lbs. per yard, while the inner, which was fixed on the inner edge of the towpath, weighed 9.1 lbs. per yard. These rails, which were of the flange type, were laid partly on sleepers ballasted with gravel and partly on blocks of concrete, weighing 220 lbs. each in the case of the heavier principal rail, and half this in case of the other rail. This arrangement costs more per mile than the sleepers, but has been found less expensive to maintain. The conductor for the current was supported on pine posts 23 ft. long, located 35 to 44 yards apart. It consisted of 8-millimeter wire, carried by porcelain insulators. The principal rail served as a conductor for the return current. The extreme dimensions of the towing locomotive were 6 ft. 10 ins. in length by 4 ft. 10 ins. wide. Its total weight was 2 tons; but the motor was so placed that only one-fifth of this total came on the accessory rail. The motor provided was much more powerful than necessary for the work in hand, as it was capable of working at the rate of 14 to 15 HP. The resistance requisite to call forth the full powers of the motors was in some of the experiments provided by rafts.

THE NAVAL ESTIMATES for the year beginning Sept. 30, 1900, call for an expenditure of $40,000,000 divided as follows: Construction, $20,000,000; yards and docks, $13,000,000, and repairs, $7,000,000.

A FLOATING DRY DOCK OF 16,500 tons capacity is to be built by Swan & Hunter, of New Castle-on-Tyne for the British Government. The new dock is to be located at Bermuda and will replace the one now in use at that port. It will be 545 ft. long and 126 ft. wide, and will accommodate the largest vessels of the English navy. In a letter to the San Francisco "Bulletin," from which the above information is taken, Messrs. Swan & Hunter give the following interesting facts regarding the Havana floating dry dock: The contract for the dock was placed with us in December, 1896, and it was an essential condition that it should be completed and delivered in the Port of Havana within eleven months from the date of contract. As a matter of fact, it was delivered about ten days before the contract date, and we, as the builders, are proud to have established a record in having completed so large a structure in so short a time, including a long voyage across the ocean. Next, we should explain that the dock was towed from the River Tyne to the port of Havana by a steamer specially chartered by us and adapted for the purpose of towing. The vessel was a steamer of 4,219 tons gross, 2,500 HP. In addition to this vessel, we sent out a powerful tug to render assistance when necessary. The dimensions of the dock are 450 ft. by 109 ft., and the weight about 5,000 tons and the lifting power 10,000 tons.

WATER SUPPLY LITIGATION AT MENOMINEE, MICH.

An interesting suit between the municipal authorities of Menominee, Mich., and the Menominee Water Co., involving the franchise rights of the latter, has recently been decided by the Supreme Court of Michigan in favor of the company, and the case presents some features worthy of discussion. In brief, the city attempted to annul a franchise granted to the Menominee Water Co. in 1884, and it is rather curious to note that the city gave the company credit for fulfilling all of its obligations during the entire period of its existence, such admissions being rarely made where corporate and municipal questions are involved in controversy. The origin of the suit lay, according to our information, in the fact that the city unfortunately (though acting under engineering advice) so constructed its sewer system that one portion discharged into Green Bay, not far from the place the city had selected for a source of water supply. The conditions of the franchise were such, that if the city became at any time dissatisfied with the quality of the water supplied, it was to bear the expense of extending the intake mains farther into the bay. Owing to the above conditions, action was threatened on the part of the company to lessen the danger of pollution, in accordance with plans urged by the company's engineer, and recommended by Mr. George H. Benzenberg, M. Am. Soc. C. E., and Dr. H. B. Baker, Secretary of the State Board of Health, acting jointly for the city and the water company. This led the city to set up a claim or plea that the company's franchise was not a legal one. The water company, having confidence in the validity of its grant, offered to enter into a friendly suit to be carried to the Supreme Court, each party to pay its own court expenses. The lower court decided the case in favor of the city. It was then argued before the Supreme Court and was there decided in favor of the company (all of the judges concurring).

The real question at issue was whether the general laws of the State, under which the city and the company had acted in good faith, would be held to control; or whether these laws should be modified by the various sections in the Menominee city charter, which had been granted prior to the grant of the franchise to the water company.

The city was incorporated by the Legislature in 1883. On May 5, 1884, the Council passed resolutions under the Water-Works Act (Section 1 of Chapter 84, Howell's Statutes), declaring it expedient that water-works should be constructed, but that it was inexpedient for the city, under the power granted in its charter, to build the works. On the same day, the Menominee Water Co. was organized under the authority of the above act. In May and September, two ordinances were passed making a contract with the company for a supply of water to the city, the hydrant rental to be $75 per hydrant for the first 75, and $60 per hydrant for all others. The company accepted the terms of these ordinances, and began the construction of its works, which were completed in 1885. In November, 1890, when the company had 135 public fire hydrants in use, the city passed ordinances requesting the company to extend its pipe system to the aggregate length of 20 miles, to erect 141 additional hydrants, and to make other improvements. This was modified by another ordinance in December, 1891. Both were accepted by the company and their terms complied with, the hydrant rental being reduced to $50 per annum. Until June, 1897, the city paid the hydrant rental provided for in the contract without objection, and at that time there were 276 hydrants in use. On June 7, 1897, however, the Council passed a resolution declaring the rental to be excessive, and its unwillingness to pay more than $10,000 per year. The company, therefore, instituted a friendly suit to recover the sums of $1,920 and $1,925, with interest, for hydrant rentals from May 1 to Nov. 1, 1897, and Nov. 1, 1897, to May 1, 1898.

In this suit the city was represented by its solicitor, Mr. L. D. Eastman, and Mr. George G. Greene, of Green Bay, Wis. The water company was represented by Brown & Truedell, of Menominee, and Hon. William A. Lynch, of Canton, O., who has been president of the company from the date of its organization. The Menominee water-works plant was designed by Mr. H. F. Dunham, M. Am. Soc. C. E., who has been the company's engineer and manager.

The essential part of the decision of the Supreme Court is given below:

It is contended by counsel for the city: (1) That the city had no power to make the contract sued upon for the reasons: (A) That the city charter prohibits it; (B) That the contract is not saved from the prohibition by Chapter 84, Howell's Statutes. (2) That there can be no recovery without the contract. It is also contended by the city that there is a conflict between the Water-Works Act and the charter, and that the charter being the later expression of the legislative will it must prevail.

On the other hand, it is claimed by counsel for plaintiff that the act "ex proprio vigore" (of its own power) does not affect any city in the state; that it is permissive and not obligatory; that it becomes effective in such cities (and in such cities only), as shall choose to avail themselves of its provisions; and that, therefore, within the contemplation of the legislature, the act was to have the same application to cities thereafter organized as to cities existing at the date of its passage.

It is admitted by plaintiff's (water company's) counsel that under the provisions of Section 15 of Chapter 26 of the original charter a contract could be made only for a period not exceeding one year and only in pursuance of a prior appropriation. It is said, however, that the city was embarrassed by that restriction and in this emergency a legislature speaking to it in the Water-Works Act said: "If you deem it expedient to have water-works constructed, but inexpedient to build such works under the power granted you by the charter, then you may avail yourself of the provisions of this act. You are not bound to do it. The act does not touch you, or affect you, unless you so elect. But if you would enlarge your power so that you may contract for a supply of water from the one year prescribed by your charter to any number of years less than 30, you are privileged to do so."

But the court below was of the opinion, and so stated, that "Chapter 84 of How. Stat., enacted in 1869, and the provisions of the charter of Menominee enacted in 1883 are in 'pari materia' and cover the same subject matter; that a subsequent legislative act repeals all prior acts repugnant to it; that the last expression of the legislative will must be carried into effect as the law of the land. . . . . Here the later law is the local, special act and the prior law a general one . . . . Chapter 84 related to all the cities of the state as they existed at the time of its enactment. Defendant's charter relates to the defendant city and was enacted 14 years later than the said Chapter 84." The court therefore held that Chapter 84 did not save the contract from the charter prohibitions.

Counsel for plaintiff contends, however, that the court below was in error in its conclusion. It is his contention that it is inaccurate to say that the prior law is the general one in the sense in which that phrase is commonly applied to ordinary legislation operating by force of its own terms throughout the state or a limited district of the state; that the act comes into being and therefore becomes local and special as to every city which avails itself of its provisions; that it speaks from the date of its adoption; that the charter deals with the ordinary conduct of the affairs of the city; that the Water-Works Act deals solely with the subject of water-works and a water supply, and that therefore these special provisions in regard to this particular subject prevail over the general provisions of the charter; that this view of the subject is consistent with and leaves untouched Section 5, Chapter 26 of the charter, which reads as follows:

The aggregate amount which the council may raise by general tax upon the taxable real and personal property in the city for the purpose of defraying the general expenses and liabilities of the corporation, and for all purposes for which the several general funds mentioned in Section 3 of this chapter are constituted exclusive of taxes for school and school house purposes, shall not, except as herein otherwise provided, exceed in any one year 1%.

We think the court below was in error in its conclusions. The constitution of this state by Section 13, Article 15, provides for the organization of cities and villages and provides that the legislature shall restrict their powers of taxation, borrowing money, contracting debts and loaning credit. Subject to such general restrictions the powers to be granted cities are left to the discretion of the legislature. The discretion of the legislature may as well be exercised in an independent statute as in the charter itself; and it was properly exercised in relation to the subject of this contract under the Water-Works Act. This act is a substantive and independent enactment. The city having availed itself of its provisions, the act stands a part of its charter as a separate chapter dealing with the specific subject of a water supply. When so read, the case comes directly within the principles laid down in Monroe Water-Works Co. v. Heath, 115 Mich., 277.

The court below, however, was of the opinion that the contract was invalid under the rules laid down in: Putnam v. Grand Rapids, 58 Mich., 416; Niles Water-Works v. Mayer, 59 Mich., 311; Ludington Supply Co. v. City of Ludington, 78 N. W. R., 558. The case of Putnam v. Grand Rapids, however, turned upon the construction of the charter of that city. In Niles Water-Works Co. v. Mayer, it appeared clearly that the contract was under the charter. It was treated so; and there is no claim in the case that any reliance was placed upon the water-works act as giving the contract validity. In Ludington Supply Co. v. City of Ludington, this court found authority in the charter to sustain the contract, and the question here raised was not presented.

The judgment below must be reversed and a judgment entered here in favor of the plaintiff for the amount of its demand, with interest.

THE NEW COVERED WATER-WORKS RESERVOIR AT PITTSFORD, VT.

A 150,000-gallon covered reservoir has been built this year by the Pittsford Aqueduct Co., of Pittsford, Vt., making a second structure of the sort connected with the water supply of the village. The engineer for the second reservoir was Mr. E. L. Grimes, of Rutland, Vt.

The water-works plant was built in 1890 with Chappell & Burke, of Rutland, as engineers. The supply is from springs, located some three miles from and 600 ft. above the reservoirs, with which the springs are connected by means of a 3-in. cast-iron pipe. The old reservoir is circular, 20 ft. in diameter and 9 ft. in available depth, giving an available storage capacity of about 15,000 gallons. It is covered by a brick dome, 8 ins. thick, with a rise of 3½ to 4 ft., resting on rubble masonry side walls. The works were originally intended for domestic service only, but fire hydrants were set when the mains were laid. Until two years ago there was no fire draft. In the summer of 1899 a fire occurred and the water in the old reservoir was drawn down, so air was taken into the supply main and the pressure dropped from 80 to 12 lbs. The supply main is 6 ins. in diameter and about two miles long. It is provided with air valves at the summits.

The new reservoir is 25×65 ft., not including two semicircular ends of 12½ ft. radius, and has 10 ft. of available depth. The side walls are of rubble masonry, 4½ ft. wide at the foundation, and 3 ft. at the top, above which is a skewback coping 2½ ft. wide at the base and 14 ins. thick. The roof consists of an arch, with an 8-in. ring, 18-ft. radius and about 5-ft. rise, the ends being covered with semi-domes of the same radius. There is a manhole at each end of the roof, with a ventilated cover. The reservoir has a bottom of 1 to 3 to 6 concrete, 6 ins. thick. The whole interior of the reservoir, bottom, sides and arch, is plastered with a ½-in. coat of 1 to 1 cement. Portland cement was used throughout. The roof is covered with earth, 3 ft. deep at the crown.

A three-way valve is placed just above the old reservoir, which is only a few feet from the new one, so either or both reservoirs may be used. Each reservoir has an overflow. The cost of the new reservoir was about $7,000.

BIDS FOR SIX ARMORED CRUISERS will be received by the U. S. Navy Department until Dec. 7, 1900. The plans and specifications may be examined upon application to the Department on and after Oct. 8 and forms of proposal and contract will be furnished after Oct. 15, 1900.

TELEGRAPHING AND TELEPHONING simultaneously over the same line is practiced quite extensively in the fire-alarm system of Berlin, Germany, according to a recent consular report. Each fire brigade cart carries a portable telephone set which may be plugged in at the nearest fire-alarm post. Each post is provided with a telegraph instrument and a number of posts are connected on the same line, but the use of the telegraph does not seriously interfere with telephoning.

A NEW ACETYLENE GAS GENERATOR.

Of the making of acetylene gas generators there has been no end during the past few years. Ever since the discovery that calcium carbide could be produced commercially at a reasonable cost, a host of inventors have been at work on the apparently simple problem of devising an apparatus for the generation of gas from that material.

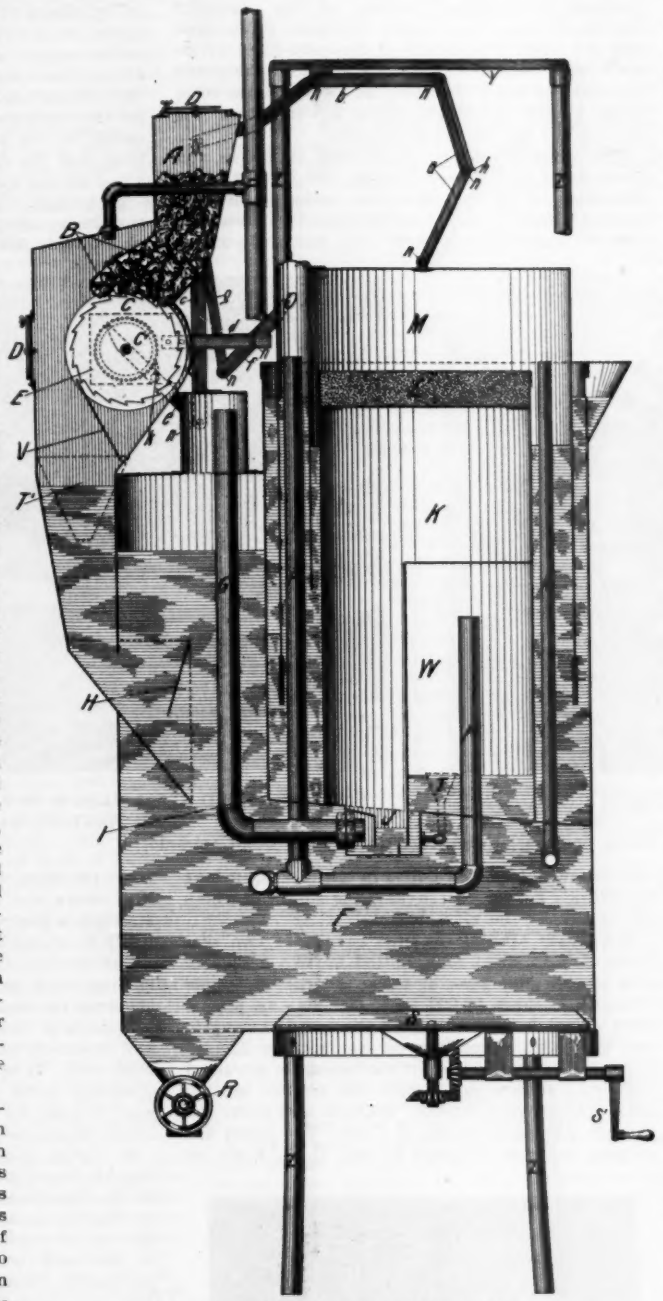
As most of our readers will recall, the addition of water to calcium carbide causes acetylene gas to be generated, while the oxygen of the water unites with the calcium to produce quicklime. This is apparently a simple enough process; yet the task of producing a generator so absolutely

simple that ordinary household servants can be trusted to care for it, and which shall in any event be absolutely free from the danger of explosion, has taxed the ingenuity of inventors.

Three principal classes of generators have been placed on the market, as follows: (1) The water is allowed to drip upon a mass of carbide, and the rate of generation of the gas is regulated by the amount of water admitted. The ordinary acetylene bicycle lantern is an example of this class, and the failings of the same are a good illustration of the difficulties which attend the use of this type of generator.

(2) Those in which a mass of carbide is put in contact with water, and the gas generation is regulated either by the automatic lifting of the carbide from the water or by the driving back of the water by the gas generated. Many generators of this class have been operated and with fair success; but a chief defect is the labor required for the frequent cleaning and refilling of the carbide holders. It will be apparent that the lime paste which is formed by the contact of carbide with water in limited quantity acts as a seal to shut away water from the interior of the carbide lumps, causes more or less waste in the material, and makes a sticky and difficult mass to clean out and remove. The fire risk in handling the carbide, and the dirt from the spent material make this apparatus objectionable in a cellar, and it is frequently installed in some outbuilding or covered vault. But here the difficulties of freezing in severe weather have to be met.

(3) In the third class of generators, of which the one shown in the accompanying illustration is an example, the carbide lumps are dropped in small quantities into a mass of water. In this class of generators each lump of carbide is reduced entirely to quicklime before the generation of gas ceases, and this quicklime, in contact with a large mass of water, is thoroughly slaked and remains in a semi-liquid state, so that it can be removed by drawing off the water by gravity. From the point of view of practical convenience of operation, the superiority of this system to the others is manifest.



A NEW ACETYLENE GAS GENERATOR.
Eugene Bournonville, Inventor; The General Acetylene Co., 56 University Place, New York City, Manufacturers.

Another advantage of this process over the semi-dry processes, as they may be called, is that the fine particles of lime dust, which are apt to find their way into the gas with these, are eliminated in the wet or plunging process. The very fine openings in acetylene burners become rapidly clogged when lime dust is carried into them with the gas. It is also claimed that the generation of the gas at low temperature (each slaking lump of carbide being kept cool by the large mass of water in contact with it) is an important factor in securing purity of the gas and a maximum yield from a given weight of carbide. Further, the gas in rising in small bubbles through the water is thoroughly washed; in fact, the generator also serves as a scrubber.

Referring to the accompanying cut, the carbide is placed in the hopper, A, a tight cover upon which prevents it from air slaking. The bottom of this chamber is formed by the revolving drum, C, which is turned by a ratchet wheel, C'. A light swinging flap prevents the carbide falling from the hopper except when the drum is revolved. The turning of the drum to feed the carbide is effected automatically by the falling of the gas-holder, M, as the gas is used. The motion is transmitted from the gasometer cover to the ratchet wheel by a system of levers, a, b, c, d, etc. Each time the gas holder falls far enough to pull down the bent lever, I, it turns the feed drum a few degrees and a small quantity of carbide falls into the water. It passes down to the bottom and gives off its gas, which rises into the small chamber seen to the right of the feed drum. A system of shields and deflector plates prevents the gas rising into the chamber where the feed drum is located. The gas then passes down the pipe, G, through the small trap, J, into the condensing chamber, K, thence through the drying and cleansing filter, L, into the gas holder, M, where it is collected over water in the same manner as in any gas holder. The service pipe leading the gas from the interior of the holder to the house mains or to any other desired point is shown at N.

P is a blow-off pipe opening to the outer air. One branch leads from the carbide chamber and draws off any fumes from the slaking of the carbide. Another leads from the interior of the chamber, W, and gives exit to the gas in case the pressure should rise too high on account of the gas holder being prevented from rising by accident or through mischief. A third branch is covered by a telescopic pipe in the gas holder, which rises and uncaps it when the gas holder reaches the limit of its travel.

The care of this generator is exceedingly simple. The carbide is emptied into the hopper as coal is fed to a furnace, and this need be done only once in several days, depending on the extent to which light is being used. The amount of carbide left in the hopper can be seen at any time by raising the cover. The lime sludge in the bottom of the generating chamber need be cleaned out only at occasional intervals. To clean it the valve, R, is opened, and the water and lime flows out through the discharge pipe. To stir up the lime in the bottom the crank, S', is turned, revolving a scraper in the bottom of the generator chamber. This pipe may be connected to the sewer, or the lime water may be utilized as a disinfectant or fertilizer, or in any other desired manner. Fresh water is supplied to replace that drawn off with the lime, and the cleaning is complete.

The cut herewith shows the apparatus as made in sizes to supply 5, 10, 15 or 20 lights. In larger size machines the generator and the gas holder are separate from each other; but the principle and method of operation are the same in all essential details. The machine has been approved by the National Board of Fire Underwriters.

The apparatus is covered by U. S. patents issued to Eugene Bournonville, and numbered 617,832, 627,498, 627,499 and 640,175, and it is also patented in numerous foreign countries. These patents are owned and the apparatus is manufactured and sold by the General Acetylene Co., 56 University Place, New York city. Among those interested in the company are several officers of the Pennsylvania Steel Co. The Treasurer of the company is Mr. Jas. G. Parsons, son of Mr. Geo. W. Parsons, M. Am. Soc. C. E.

Several hundred of these generators have already been manufactured and put into service with results entirely satisfactory to the users. Among recent installations is a plant for lighting a suburban station on the Central Railroad of New Jersey.

A word or two as to the cost of lighting with acetylene may be of interest in conclusion. Calcium carbide costs about 5 cts. per lb., and a pound generates about 5 cu. ft. of gas. The ordinary acetylene burner gives about 25 candle power and uses about ½ cu. ft. of gas per hour. Thus the cost of the carbide may be set at about ½ ct. per lamp hour. Quarter-foot burners may be installed where a smaller light is sufficient. The gas is burned in a flat flame, and there is no expense for chimneys or mantles. The light, as most of our readers know, is intensely white and brilliant. While ordinary carbide may be used in the above described generators, a special screened carbide is furnished at slight additional cost which has been treated to an oil bath. The action of the water on the oil-treated carbide is slightly delayed, so that it does not begin to generate gas until it has fallen below the deflecting plate, H (see cut), thus preventing loss of the gas generated in falling through the first foot or two of the water. The dust, which would float on the surface of the water and give off its gas to the carbide chamber, thence to pass off by the waste pipe, is also extracted by the process of screening.

NINE-FOOT WOOD STAVE PIPE, FLORISTON PULP AND PAPER CO., FLORISTON, CAL.

By D. C. Henny, M. Am. Soc. C. E.*

The Truckee River, flowing out of Lake Tahoe and reinforced by various small creeks and streams, affords a fine opportunity for the development of water power on account of the rapid fall at certain points, the ease with which the water can be diverted, and the fact that Lake Tahoe itself can be used as a storage reservoir to increase the natural summer flow of the river.

*Manager Excelsior Wooden Pipe Co., 204 Front St., San Francisco, Cal.

Some small power plants near Reno, Nev., have been in operation for several years, but it was not until last year that the development of any large amount of power from the Truckee River had been attempted. The Floriston Pulp & Paper Co. acquired rights to the water of the stream for power purposes near Floriston and this company has since constructed a large paper mill which is entirely run by water power.

Water is diverted from the stream at a point where a timber crib dam could be economically built. The dam as built is 140 ft. long at the top, and has a spillway over the center of the dam 68 ft. long at an elevation 16 ft. above the bed of the stream, which is bed-rock at this point. The height of the spillway above the river bed was limited on account of the main track of the Central Pacific passing through the canyon at an elevation, at the point of the dam, of about 24 ft. above the river bed. At the north end of the dam, an outlet and sluice gates are provided, while at the south end there is constructed in the dam the head gate leading the water into the pressure pipe. About 2,400 ft. down stream from the dam the paper mill has been constructed, consisting of a number of brick buildings, provided with the necessary machinery for manufacturing paper from pine, spruce, tamarack and cottonwood logs, supplied from the abundant forests in the vicinity.

The power used is taken from seven wheels, furnished by S. Morgan Smith, of York, Pa. The aggregate power of these wheels is 5,400 HP., which is in excess of the average power that will be used and that is ordinarily available, but which arrangement permits of the use of a large proportion of the entire power at hand for any one of the several departments.

The wheels receive their supply from a steel receiver, 9 ft. in diameter and about 300 ft. long, running parallel to the river, partly outside of and partly through the buildings. The wheels supplied from this receiver are placed away from the river and discharge their water into masonry tail races, which cross back under the receiver on their way to the river. The water is conducted from the dam to the end of the steel receiver through a 9-ft. wood stave pipe, 2,200 ft. in length, placed with its bottom at the upper end about 17 ft., and at the lower end about 48 ft., below the crest of the spillway. The total average fall with 2 ft. of water over the spillway is 58 ft., varying somewhat with the height of the water in the tail races.

At certain seasons of the year it is expected that the full flow of the river will pass through the pipe, at which times the total available pressure upon the wheels is figured to be about 54 ft., which with a velocity of water of 5 ft. per second, equivalent to a flow of 19,000 cu. ft. per minute, will deliver to the wheels water enough to furnish 1,940 HP. From this, in order to arrive at the net horse power, the loss through the wheels should be deducted. During most of the year the flow through the river is in excess of the quantity named, and, as the increase of friction in the pipe is but a small percentage of the total head available up to velocities of 12 ft., the total horse power delivered to the wheels may at certain times come close to the aggregate horse power which the wheels are capable of developing.

The wood stave pipe was built of staves run from 4 x 6-in. redwood lumber, and having a net thickness of 3¾ ins., 64 staves being required to complete the circle. The redwood used was clear and free from all imperfections. The butt ends of the staves are slotted and joined in the pipe by means of metallic concealed tongues, the slots for which are shown by the view, Fig. 1.

The bands around the pipe consist of two sections of ⅝-in. steel rods, united by two malleable pipe shoes. The steel of these rods has a tensile strength of from 58,000 to 65,000 lbs., an elastic limit of not less than 60% of the tensile strength, and shows an elongation on test of over 22% in 8 ins. The top section of the bands is provided with two square heads and the bottom section with cold-pressed threads, washers and nuts, the threads having a length of 7 ins. The shoes are similar to those patented by Mr. C. P. Allen, of Denver, and have a length of 8 3-16 ins. over all and a width of from 2⅝ to 2¾ ins. The maximum pressure upon the wood at the tail end of the shoe, supposing the bands to be cinched to the breaking point, is 1,060 lbs. per sq. in. The bands are spaced at the upper end, 10 ins. apart, the spacing gradually diminishing towards the lower end as the pressure increases until they are 4¾ ins. apart at the lower end, where the pressure is 50 ft., and where the pipe is connected with the steel receiver.

The alinement of the pipe is on tangents, connected by sweeping curves, generally of 1,200 ft. radius, except that at a point about 400 ft. down stream from the dam a steel elbow, Fig. 2, was introduced, made of riveted steel, with large bells for the reception of wooden pipe. The joints were calked in the ordinary manner with oakum and lead, and the ends of the wooden pipe were provided on the inside with steel reinforcing rings.

To protect the stave pipe from water hammer, two 20-in. steel standpipes were placed upon it, respectively 200 ft. and 1,000 ft., down stream from the dam, extending 2 ft. above high water line above the dam. There are also two 30-in. standpipes placed upon the steel receiver, extending 4 ft. above high water line.

The method of construction of the stave pipe is illustrated by the accompanying views, Fig. 3 showing the character of the interior. The pipe is generally bedded to the center line in earth and boulders, only a portion being entirely covered over. It is the intention of the company to gradually cover the entire pipe with earth to prevent drying out of the lumber from the outside, which would eventually cause decay.

As stated, the plant was built by the Floriston Pulp & Paper Co., of which Mr. L. Schwabacher, of San Francisco, is general manager, and Mr. W. P. Hawley is local manager and superintendent. Mr. Ed. S. Cobb, of San Francisco, was engineer on the work, which was done under contract by the Pacific Construction Co., of San Francisco, except the wooden stave pipe, which was built by the Excelsior Wooden Pipe Co., of San Francisco. The works have been in operation since the middle of May, 1900.

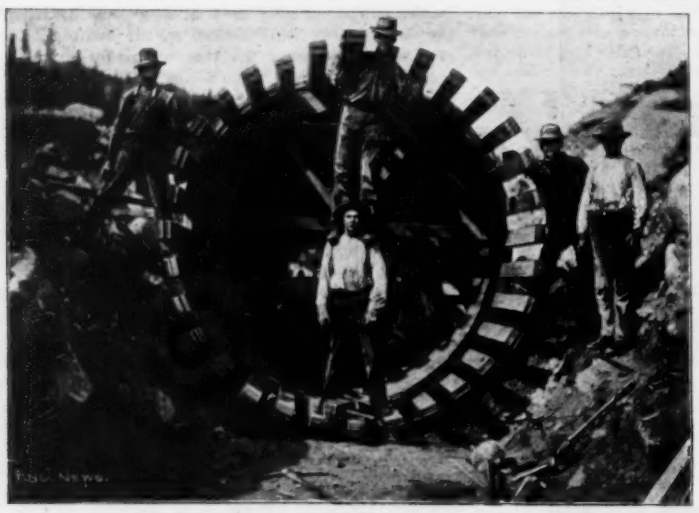


FIG. 1.—VIEW OF 9-FT. REDWOOD PIPE UNDER CONSTRUCTION, NEAR FLORISTON, CAL.

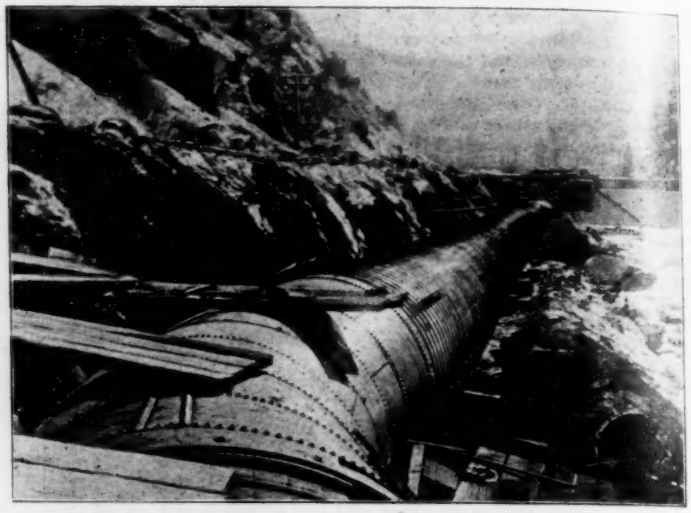


FIG. 2.—RIVETED STEEL ELBOW IN 9-FT. REDWOOD PIPE, NEAR FLORISTON, CAL.

Mr. E. S. Cobb, Engineer; Excelsior Wooden Pipe Co., Contractor.

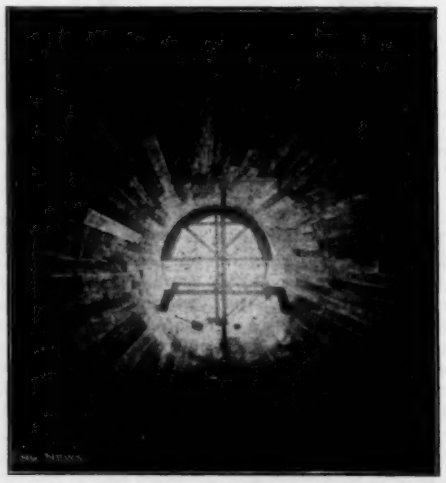


Fig. 3.—Interior View of 9-ft. Redwood Stave Pipe, Near Floriston, Cal.

HIGH HYDROSTATIC PRESSURES AND A NEW FORM OF PRESSURE GAGE.*

By Francis H. Stillman,† M. Am. Soc. M. E.

Last year there was supplied to the West Virginia Agricultural Experiment Station, a small press for some test work which they desired to do, in determining the effect of high pressures upon the bacteria which appear in milk. Mr. B. H. Hite, the chemist at the station, as a result of their experiment, published in the "American Chemical Journal," of July, 1899, an article upon the method for carrying out chemical reactions under high pressure, and the station has issued a bulletin giving the results of the milk experiments. These papers referred to pressures which I questioned (as high pressures are frequently incorrectly reported), and in reply I received a letter from Mr. Hite, in which he stated that he "had repeatedly had pressures of 45 tons upon a piston ½-in. in diameter." This corresponds to over 450,000 lbs. per sq. in.; no allowance being made for the loss in frictions of packings and parts. In reply to a letter asking the privilege of submitting his experiments to the American Society of Mechanical Engineers, Mr. Hite has sent me an article so much more interesting that I take pleasure in presenting almost the entire matter sent to me, adding some items from the above-mentioned articles.

*Condensed from a paper read before the American Society of Mechanical Engineers.

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In order to subject a liquid to pressure, the capacity of the vessel containing the liquid must be decreased. This suggests at once a cylinder and piston, but no simple cylinder and piston will hold a liquid under very high pressure, for no matter how well the piston may be ground to fit the cylinder a high pressure will expand the cylinder (not to say contract the piston) thus leaving a space between them through which the liquid will escape. It seems to be practically impossible to obtain such contact between the packing and the piston and cylinder that a liquid under high pressure will not force its way out. Indeed, about the only contact that is equal to such cases is that between the particles of one continuous piece of metal, from which it would appear that in order to secure the highest pressures, the end of the piston and walls of the cylinder would have to be one solid piece for all positions of the piston: or that the liquid would have to be completely encased in one unbroken piece of metal. If these conditions could be realized, the pressures obtainable would be limited only by the strength of the materials used in the construction of the cylinder. A description of such a method follows:

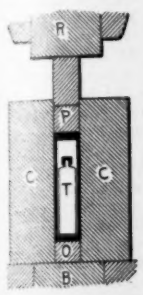


Fig. 1. Section of Apparatus for Subjecting Liquids to Very High Pressures.

The liquid to be subjected to pressure is placed in a lead tube (shown in the section, Fig 1, as a heavy black line surrounding the tube T) which is then closed with a lid of the same material and placed in a heavy steel cylinder C C, the lower end of which is closed with a steel plug O, the upper end, with a steel piston P. B is the bed plate and R, the ram of a hydraulic press.

In working with liquids that will attack the lead tube (e. g. strong acids) these may be placed in the thin-walled screw-cap collapsible platinum tube T, which is then placed inside the lead tube, the intervening space being filled with water. This platinum tube simply serves to separate the liquid within it from the water surrounding it, and is, of course, unnecessary in working with liquids like water or alcohol which do not attack the lead. The cylinders used were 5 ins. in diameter and 7 ins. long. The inside diameter varied from ½-in. to 1¼ ins. With such cylinders the following pressures may be obtained:

1¼ ins.	in diameter.....	100,000 lbs.	to 150,000 lbs.
1 "	" "	100,000 "	" 200,000 "
¾ "	" "	200,000 "	" 300,000 "
½ "	" "	300,000 "	" 400,000 "

Most of these cylinders have been forced to higher pressures, but always with more or less injury to them.

Most of them were made of one piece of tool steel, although quite a number of them were built up of concentric pieces shrunk together. The best results were obtained with cylinders made by Brown & Sharpe, of one piece of special tool steel from the Howe-Brown Co., which, without much tempering, was hard enough to keep its shape; but no matter how hard the material may be, the cylinder will yield more or less under high pressures, and for this reason it is better to make the plug O and the lower piece of the piston P of softer steel, so that under the pressure these may also spread. This was found to be absolutely necessary in working with the ½-in. cylinder under the higher pressures named. Indeed, with this arrangement, even higher pressures than those above given have been obtained; but in these tests the cylinders suffered considerable injury.

It will be observed that it is the continuous lead packing that is responsible for the high pressures obtainable with this device, and it should be stated that, no matter how high the pressure may be, there is never even so much as a trace of a leak while the pressure is being applied. On removing the pressure the liquid, in expanding to its original volume, will often loosen the lid of the lead tube; and in case very high pressures have been used, the lead tube, in stretching to its original capacity, will often be pulled completely in two. Liquids are by no means "practically incompressible" when they get into this machine. The expansion on relieving the pressure is very apparent, and so great that you could measure it with a rule. Even in working with some of the lower pressures a column of water 5 ins. long will expand a half inch or more.

The compressibility of liquids may, under these high pressures, be very accurately determined in the following manner: The little picnometer bottle (shown in the middle of Fig. 2, and differing from an ordinary glass-stoppered bottle only in that the top of the stopper is expanded into a little bowl or cup which, when the stopper is in position, communicates with the interior of the bottle by means of a very fine capillary hole through the stopper) is weighed accurately, empty, then weighed full of mercury, which, of course, gives the weight of the volume of mercury necessary to fill the bottle. The mercury is then poured out and the bottle filled with the liquid whose compressibility is to be determined, the stopper inserted firmly, and a quantity of mercury poured into the little cup. Although the mercury is much heavier, of course, than the liquid (e. g. for example, water) in the bottle, the mercury cannot enter the bottle, because the water and mercury cannot pass each other in the capillary hole. Any difference in pressure, however, will allow either the mercury to flow into the bottle, or the liquid within the bottle to flow out, depending upon whether the pressure is higher without or within the bottle. The little bottle loaded in this way (with mercury in the cup, and the liquid whose compressibility is to be determined in the bottle) is placed in the lead tube, which is then filled up with water and subjected to pressure in the usual way, when just enough mercury will enter the bottle (and fall to the bottom) to make up for the compression experienced by the liquid (water) in the bottle under the pressure applied. On removing the pressure a quantity of the liquid (not the mercury) will be forced out through the stopper; but this does not matter, as everything is estimated in terms of the mercury, which is then poured out, dried, and weighed, and from the weight of this quantity of mercury and the weight of the quantity required to fill the bottle the compressibility of the water liquid is estimated. This, of course, neglects the compressibility of the small quantity of mercury that found its way into the bottle while the pressure was being applied. This will have to be estimated in a special determination in which a slightly different bottle is used. For this determination the top of the stopper need not be expanded into a cup, but the lower end of the stopper must extend some distance into the bottle, which is simply filled with mercury and weighed (the weight of the bottle having been determined), placed in the lead tube, which is filled up with water and subjected to pressure as above. In this case the water from around the bottle enters the bottle to take the place of any contraction experienced by the mercury, but, being lighter than the mercury, rises to the top (above the lower end of the stopper); and so it is a corresponding quantity of the mercury that escapes through the stopper when the pressure is removed. By weighing the mercury left in the bottle and comparing this weight with the weight of the mercury required to fill the bottle, the compressibility of the mercury under the pressure used can be determined. In this case, of course, we neglect the compressibility of the small quantity of water which entered the bottle while the pressure was being applied; but from this determination and the one mentioned above (compressibility of water), the compressibility of both the water and the mercury may be calculated.

In this way the compressibility of a number of liquids at a number of different pressures has been determined, and the compressibility of liquids containing known quantities of various substances in solution has received quite a little attention, as the results are of considerable interest from a chemical standpoint; but these latter results, however, would probably not be of so much interest to mechanical engineers. Since water and alcohol are used so extensively in hydraulic machinery, you might care to know that under a pressure of about 65,000 lbs. per sq. in. water is compressed over 10%, and alcohol more than 15%.

As I was very anxious to determine with great accuracy the difference in the compressibility of a pure liquid and that of the same liquid containing some substance in solution, and as slight errors would, of course, be introduced by the friction of the piston and by possible slight inaccuracies in the reading of the gage, the compressibility of the pure liquid and the solution were determined at the same time; that is, two bottles were placed in the lead tube at the same time, when, of course, they were subjected to the same conditions. Working in this way, of course the bottle containing the pure liquid simply serves as a pressure gage, but the results obtained in this way were so much more satisfactory that I am led to suggest one of these little bottles as a perfect pressure gage.

By means of these little picnometer bottles, as shown above, the compressibility of the liquid may be determined under any pressure up to that of the crushing strength of steel, and having determined, once for all, the compressibility of mercury and of some other liquid, preferably water, this method can be used to determine with great accuracy the pressure on the liquids in hydraulic machinery, etc.

Fig. 2. Section Showing Picnometer Bottle for Measuring High Pressures.

It would only be necessary to load one of these little bottles with water and mercury, as described, and place it in a tube communicating with the liquid in the hydraulic machine, say in some such arrangement as that shown in Fig. 2. The accuracy of pressure gages necessarily depends upon the elasticity of some material. Those in general use depend upon the elasticity of some solid. Solids are never perfectly elastic, even when subjected to relatively small strains, and the change in form which they experience as the result of pressure must be greatly magnified in order to make the gages in which they are used sufficiently delicate; and even then such gages have but a very limited range. But such difficulties are only too well known.

In this proposed gage the accuracy depends solely upon the elasticity of the water and mercury and the balance used in the weighings, and liquids are perfectly elastic; and the analytical balance has reached about as high a degree of perfection as any instrument known to science. The accuracy or delicacy of this gage hinges upon determining volumes by weighing mercury, and there is hardly a determination known to science that can be made with greater accuracy. The quantities of mercury to be weighed would, of course, depend upon the size of the bottle used; but even when working with a bottle 2 ins. long by ¾-in. in diameter, the quantities of mercury are sufficient to enable a reasonably good balance to detect differences in pressure of a pound throughout the range of the several houndred thousand pounds mentioned. A gage that would measure pressures as great as this, throughout anything like such a range, would, so far as I know, be regarded as a jewel indeed; and I can't help thinking that such a gage as the one proposed should be of more than ordinary interest to mechanical engineers; everything connected with it is so simple, and it would be such an easy matter to construct it and attach it to any hydraulic machine. It might even be used in other lines of work if placed in a lead tube and cylinder (such as above described) with a piston of definite area.

A HISTORICAL REVIEW OF RAILROAD CONSTRUCTION IN THE UNITED STATES.*

THE FIRST RAILWAYS, 1835 TO 1848.

The railroad system of this country had its birth in 1828, when the construction of the Baltimore & Ohio R. R. was inaugurated. In 1835, seven years after the commencement of construction on the Baltimore & Ohio R. R., there were in operation in the United States 1,098 miles of railroad, of which nearly all were in the states bordering on the Atlantic Ocean. Five years later the system had nearly trebled in extent, the lines then beginning to head toward the interior. The Camden & Amboy R. R., connecting Philadelphia with New York harbor, was completed in 1837. In 1841, the line from Boston to Albany was opened. In December, 1842, the line from Albany to Lake Erie, at Buffalo, was fully opened, an event second in importance only to the opening of the Erie Canal. Although restricted in the transportation of freight, for the benefit of the Erie Canal, it at once became, in connection with the lake, the great route of travel between the Eastern states and the interior. Nothing, however, was further from the minds of the parties opening this line than a competition for the business of the canals. In 1842, the Philadelphia & Reading R. R. was opened to the coal fields of Pennsylvania, and by means of this and of lines subsequently constructed, adequate supplies of the great source of power, upon which are based the industries and commerce of the country, were, for the first time, secured.

In 1840 there was in New England a well-defined system of railroads, which had Boston for a center. The Eastern R. R. was in operation from Boston to Portsmouth; the Boston & Lowell and the Lowell & Nashua formed a continuous line from Boston to Nashua; the Boston & Providence was completed to Providence, and the New York, Providence & Boston continued that line from Providence to Stonington. Of the present Boston & Albany line, three sections were then completed: from Boston to Worcester, 44.63 miles, built by the Boston & Worcester R. R. Co.; from Worcester to Springfield, 62.60 miles, built under the charter of the Western R. R. Co., and from Hudson, N. Y., to Pittsfield, Mass., 46.51 miles, making a total of 153.74 miles. The last-mentioned section was composed of a portion of the western division of the Western R. R., from the New York state line to Pittsfield, Mass.; the remaining portion, all in the state of New York, was built by what was then known as the Hudson & Berkshire R. R. Co. This left a gap between Pittsfield and Springfield on the Western R. R., which was completed in 1841; and the whole line was opened throughout in September of that year. In 1840 the Boston & Maine R. R. was being operated from Wilmington to Exeter, and the Boston & Lowell tracks were used to gain entrance to Boston. The Norwich & Worcester was in operation between Worcester, Mass., and Norwich, Conn., and the New Haven & Hartford was completed between the two points named in its title. The roads here enumerated comprised the entire system at that time of the states of Massachusetts, New Hampshire, Rhode Island and Connecticut.

In 1848 a continuous line of railway was formed between Boston and New York city by the completion of the New York & New Haven R. R., its formal opening occurring on the 1st day of January, 1849.

Early in 1851 the Erie R. R. was opened from the Hudson River to Lake Erie; and in the fall of the same year, the Hudson River R. R. between New York city and Albany was opened, completed two lines of railroad from the harbor of New York to the lakes, neither of them being subject to any other burden than the cost of trans-

*Reprinted, much condensed, from advance sheets of the Introduction to "Poor's Manual" for 1900. A similar review formed a part of the introduction to the issue of the Manual for 1899 and was reprinted in a condensed form in Engineering News of Nov. 9, 1899, but the present article covers the subject so much more comprehensively that we have abstracted it as a whole at the risk of repeating the matter already published in the previous issue. The article in its present enlarged form is undoubtedly the best and most concise historical review of railway construction in the United States which has ever been printed.

portation. Provision was now, for the first time, fully made not only for competition with the traffic of the canal, but for a participation, by railroads, on an extended scale, in the internal commerce of the country. They entered very slowly, however, upon this new field.

The future success of the trunk lines from the lakes and the Ohio to the seaboard was due to the extension of these lines, by other railroads, into the interior of the country. The tendency of freight coming from the West to Buffalo by the lake was almost irresistibly to the canal—the boats serving as warehouses for their freight both at Buffalo and New York. At that time there were no elevators, nor any adequate provision for the handling of railroad freights at all comparable with those enjoyed by the water-lines. It was consequently not until railroad communications could be had with the interior that the ground for a successful competition was fully laid. The tendency of both grain and provisions, when once loaded upon a car, was to remain in the car till their market was reached. The business of the trunk lines, consequently, grew just in ratio to the progress of the railroads in the great interior basin of the country.

Upon all freight moved from Albany to the lake, canal tolls were imposed up to 1851, for the benefit of the canals owned by the state. The Erie R. R. was opened in that year; and, as canal tolls could not well be imposed upon this work, they were removed from the Central line. The year 1851, consequently, marks a very important era in the history of the railroads of this country, as it was the first in which they began to move merchandise on any considerable scale. The total number of miles in operation that year equalled 8,876. Their gross earnings equalled $39,566,358. Their gross tonnage equalled 5,672,762 tons, assuming the tonnage of all to equal the average of those of the state of New York, which carried that year 1,093,381 tons, their mileage equalling 1,705 miles.

Up to 1848 the progress made in railroad construction was slow and unpromising, the total mileage of lines completed at the end of that year being only 5,996 miles, of which 1,225 were in New England, 2,350 in the Middle States, and 1,415 in the Southern States. Pennsylvania led the states with 1,048 miles, New York following with 869 miles, and Massachusetts coming third with 790.

During this period the construction, maintenance, and improvement of railroads had absorbed all the floating capital of the country. Small as was the progress made, it imposed too heavy a burden on the financial machinery of the nation; for so rudimentary was the industry of the country, and so slow its rates of increase, that the best-located lines, instead of creating, as they do now, an annual traffic much exceeding their cost, were a heavy charge upon the promoters and stockholders.

The first great movement in the construction of railways dates from the discovery of gold in California in 1848. The effect upon the industries and commerce of the country, of the sudden addition of more than $50,000,000 annually, to its circulating medium, was prodigious. It had no precedent in history. The acquisition of California was equivalent to the acquisition of half a continent. A new field was opened, which absorbed no inconsiderable portion of the labor of the country at most remunerative rates. All sections were proportionally benefited. The wealth drawn so copiously from the Western part of the continent stimulated to an extraordinary degree the commerce, manufactures, and trade of the Eastern. For the increased wealth and newly-created enterprise of the nation, the railway offered the most attractive and appropriate field. Foreigners shared fully with ourselves in the enthusiasm which prevailed, and proffered almost unlimited sums for the prosecution of our public works. From 1849 to 1857, 17,138 miles of railway were constructed. Then came a great commercial revulsion, which, commencing in the United States, swept around the world. But the nation had grown too strong to suffer anything more than a temporary check. The lines of railroad which had been constructed penetrated every important portion of the country, and gave a high commercial value to its products. Labor everywhere was thus enabled to reap, even in the midst of the great depression that prevailed, a remunerative return. An immense stride had also been made in contrivances for abridging labor, particularly in agriculture; so that two or three years sufficed not only to restore the loss of the past, but to enable our people to start anew upon their career, which has for its end and object the complete utilization of the resources and wealth of a great continent.

Such is a brief sketch of the earlier attempts at railroad construction in the United States. An extraordinary and most unhealthy stimulus was given to the construction of railroads and canals by the wild and extravagant spirit of speculation which swept over the country, commencing in 1834, and coming to a sudden end in 1837. A vast number of chimerical schemes were entered upon, and large sums expended or pledged for their construction. In addition to private undertakings, a large number of the states entered upon the construction of elaborate systems of internal improvements, nearly all of which, with the private enterprises, were suddenly overwhelmed in a common ruin. Not a tithe of what was undertaken was accomplished. For the want of means of communication the products of the interior, such as they then were, still possessed very little commercial value. At that time only a very few of the mechanical contrivances existed which have since abridged labor to such an extent that the productive capacity of society, in proportion to its numbers, had been quadrupled within the last thirty years. The means for a speedy recuperation had not then been created. Years, consequently, were required to repair the waste and loss that had been suffered. After resuming from the suspension of 1837, the great majority of the banks of the country again suspended payment in 1842. The period from 1837 to 1844 may be set down as one of the most gloomy and disastrous in the history of the country.

The works first built were cheap and rude structures, adapted neither to high speeds nor heavy trains, and formed a most striking contrast to the almost perfect works of the present day. The estimated cost of many of the most important lines in the country did not equal one-half their annual receipts at the present day. That of the Erie R. R. was $6,000,000. A revised estimate made as late as 1841, after considerable progress had been made with the work, put the cost of the road at only $9,000,000. The inadequate estimates made in almost every case were a fruitful source of future embarrassment, while the imperfect structure of most of the roads not only greatly restricted their traffic, but involved heavy losses from the reconstruction, which was in almost every case rendered necessary.

The earlier roads, instead of possessing, as at present, an annual traffic exceeding in value many fold their cost, were a heavy burden upon the capital and industry of the country. In many of the states, particularly in the Western and Southern, large sums were expended upon lines which were wholly abandoned. Still larger sums were wasted in attempts to construct canals and in extensive systems of banking, which were set on foot in nearly all the states. The railroads constructed were mostly short passenger lines, and contributed little toward the development of the material interests of the country. So excessive were the losses, and so complete had been the disorganization of the industries of the country in the great revulsion that followed, that years were required to restore the waste and exhaustion that had been suffered.

From the opening of the first railroad in 1830 to 1848, inclusive, a period of nineteen years, 5,996 miles of line had been completed, being an average of 316 miles annually.

The following statement exhibits the progress made annually in railroad construction in the whole country from 1849 to 1860:

Year.	Miles in Operation.	Increase of Mileage.	Year.	Miles in Operation.	Increase of Mileage.
1849.....	7,365	1,369	1855.....	18,374	1,654
1850.....	9,021	1,656	1856.....	22,016	3,642
1851.....	10,982	1,961	1857.....	24,503	2,487
1852.....	12,908	1,926	1858.....	26,968	2,465
1853.....	15,360	2,452	1859.....	28,789	1,821
1854.....	16,720	1,360	1860.....	30,635	1,846

FROM 1848 TO THE CIVIL WAR.

In the nineteen years, 1830 to 1848, there were constructed 5,996 miles of railroad in the United States, of which only 419 miles were in the Western states. During the twelve years from 1849 to 1860 there were added 24,639 miles of line, making the total at the end of the latter year 30,635 miles, an increase over 1848 of 400%, and an annual average of over 2,000 miles, as against an average of 316 in the first period.

After Lake Erie was reached, the next great step was the extension of the Northern system of railroads to Chicago by the completion, in 1853, of the Cleveland & Toledo (now a part of the Lake Shore & Michigan Southern) R. R. The Michigan Central & Michigan Southern, extending from Lake Erie to Chicago, were opened in 1852, ten years after the opening of the main line of the New York Central from Albany to Buffalo.

The construction of the Pennsylvania R. R., now one of the most important of our public works, was begun in 1847. It was opened for business in 1854. This line was extended to Chicago by the Pittsburg, Fort Wayne & Chicago, which was completed in 1858. The Baltimore & Ohio R. R., the first undertaken in the United States, was opened on the 12th of January, to the Ohio, at Wheeling.

In the preceding sketch we have briefly recapitulated the works first undertaken, and have traced the progress westward of the great trunk lines based upon Boston, New York, Philadelphia, and Baltimore. Some progress had, however, been made in the valley of the Mississippi before either of those lines had reached that valley or Lake Erie. The first line of railroad undertaken in the great interior basin of the country was the Mad River & Lake Erie of Ohio, afterward a part of the Cincinnati, Sandusky & Cleveland Ry., which line was purchased in November, 1890, by the Cleveland, Cincinnati, Chicago & St. Louis Ry. Co. Its construction from Sandusky to Dayton, 154 miles, was begun in 1835, a portion of it being opened in 1838. In connection with the Little Miami, which was opened from Cincinnati to Springfield in 1846, it formed, in 1848, a part of the first through line from Lake Erie to the Ohio. A second line between the lakes and river was formed by the Little Miami and the Cleveland, Columbus & Cincinnati, which was completed between Cleveland and Columbus, 135 miles, in 1851. The Cleveland & Pittsburg, forming the third line, was opened in 1852. These roads opened up the greater part of the state of Ohio to transportation by railroads, and supplemented the trunk lines westward, so soon as the intermediate links could be put in. This was accomplished by the completion of the line of railroad from Buffalo to Toledo, the last link of which, between Cleveland and Toledo, was opened in 1853. Of the lines running east and west through that state, the first to be constructed was the Central Ohio, which was opened from Wheeling to Columbus, 137 miles, in 1854. The Marietta & Cincinnati R. R. was begun in the spring of 1851, and six years later was completed from Marietta, on the Ohio River, to Loveland, 173 miles; entrance into Cincinnati, six miles beyond Loveland, being made over the tracks of the Little Miami R. R. In 1857, the same year that the Marietta & Cincinnati was completed, the Baltimore & Ohio reached the Ohio River at Parkersburg, by the construction of its Parkersburg branch; and two years later a branch of the Marietta & Cincinnati was built to meet the latter line, thus forming a through line from Baltimore and Washington to Cincinnati. In 1858 the Pittsburg, Fort Wayne & Chicago R. R. Co. opened its important line from Pittsburg to Chicago, a distance of 468 miles, completing the second great trunk line from New York to Chicago.

As in Ohio there were no railroads of importance constructed in the other Western states of the Union previous to 1849. In Indiana the Madison & Indianapolis (now a part of the Jeffersonville, Madison & Indianapolis), one of the roads first constructed in the West, was opened in 1847. This line was originally begun by the state, and 26 miles of it were opened in 1841. It was transferred to a private corporation in 1843, and completed between Madison and Indianapolis in 1847. The first line running east and west through the state, made up of the Indiana Central Central, and the Indianapolis & Terre Haute, was opened in 1853. The next line, having a similar direction, was the Ohio & Mississippi, opened in 1857. The New Albany & Salem, now the Louisville, New Albany & Chicago, the first line connecting Lake Michigan and the Ohio, and lying wholly in Indiana, was opened in 1854.

In Illinois the first line undertaken was the Sangamon & Morgan, a portion of which was opened as a state work in 1839. This road now forms a part of the Wabash line. The second line opened in Illinois was the Galena & Chicago Union, which was commenced in 1849, and opened for a distance of 10 miles in June, 1850. The railway first opened in this state from Lake Michigan to the Mississippi River was the Chicago & Rock Island, in February, 1854. This connection marked a very important extension of the railway system of the country. The second line to the Mississippi, made up of the Galena & Chicago and the Illinois Central, was opened early in 1855. The Chicago & Alton was opened in 1855; the Chicago, Burlington & Quincy to the Mississippi River in 1856; the Milwaukee & St. Paul in 1858, and the Western Union in 1862. Both of the latter now form part of the Chicago, Milwaukee & St. Paul system. The Chicago branch of the Illinois Central was opened from Chicago to Cairo in 1856. At this time the Illinois Central, with its 700 miles of road, was considered the most stupendous undertaking in the world.

The next important extension westward was the Hannibal & St. Joseph, which carried the railway system to the Missouri River in 1859.

Of the lines constructed through Central and Southern Illinois, the Terre Haute & Alton was opened in 1854, and the Ohio & Mississippi in 1857. From St. Louis westward, the Pacific R. R. of Missouri, the beginning of the present Missouri Pacific system, was completed to Sedalia, 189 miles, in 1861—before the outbreak of the war.

The railroads whose progress has been here sketched formed at this date, geographically and commercially, one system, of which the Baltimore & Ohio R. R. and its connecting lines may be said to constitute the southern boundary or member. South of Baltimore there was no important commercial city upon the Atlantic coast, and the trade of all the interior north of a line with the lower Ohio naturally sought eastern outlets through the railways that had been opened. In consequence, the railroad development of the Southern states during the earlier periods was slow and of local importance only.

Several railroads were constructed at an early day in Virginia, the more important of which were those now forming the line traversing the state from north to south, and made up of the Richmond, Fredericksburg & Potomac, completed from Richmond to Fredericksburg in 1837, and to the Potomac in 1841; the Richmond & Petersburg, opened in 1838; and the Petersburg & Roanoke, in 1843. But the great line of Virginia, prior to the Civil War, was the railway traversing the state diagonally from Alexandria to the boundary line of Tennessee, 382 miles, made up of the Orange & Alexandria R. R. and the Virginia & Tennessee R. R. The former of these roads was opened in 1859 and the latter in 1856. At the boundary this line connected with the East Tennessee & Virginia, extending to Knoxville, Tenn., which was opened in 1858. From Knoxville this line was extended to Dalton, on the line of the Western & Atlantic R. R., by the East Tennessee & Georgia R. R., opened in 1856.

From Weldon the Virginia system was extended to Wilmington, N. C., by the opening of the Wilmington & Weldon R. R., in 1840. It was not till 1853 that a connection was formed with the system of South Carolina by the opening of the Wilmington & Manchester R. R. The South Carolina R. R., as before remarked, was opened to Augusta, Ga., in 1833. From Augusta the Georgia R. R. was

opened to Atlanta in 1839. The Central R. R. of the same state was opened from Savannah to Macon in 1840. From Atlanta the railway systems of South Carolina and Georgia were extended to the Tennessee River at Chattanooga, Tenn., by the completion of the Western & Atlantic R. R. of Georgia, a state work, in 1850. From Atlanta a line of railway was opened to Montgomery, Ala., in 1833, and from Montgomery to Mobile, in the same state, in 1862.

From Chattanooga to Nashville the Nashville & Chattanooga was opened in 1854, and the Memphis & Charleston in 1857. The Mobile & Ohio R. R. was opened to Columbus, on the Mississippi River, near the mouth of the Ohio River, in 1859. The line from New Orleans, made up of the New Orleans, Jackson & Great Northern, and the Mississippi Central, was opened to a connection with the Mobile & Ohio, at Jackson, Tenn., the same year. The Louisville & Nashville was opened to a connection with the roads last named in 1861, and with Nashville in 1859.

The following statement gives the terminal points of the first railroad or section of railroad built in each state in the Union, with its length and date of opening:

States.	Termini of first section opened — From	To	Length, miles.	Year open'd
New Eng.:				
Me.	Bangor	Oldtown	11.00	1836
N. H.	Nashua	Mass. state line	5.25	1838
Vt.	White River	Bethel	25.00	1848
Mass.	Boston	Lowell	26.76	1835
R. I.	Providence	Stonington, Conn.	50.00	1837
Conn.	Hartford	New Haven	36.25	1839
Middle:				
N. Y.	Albany	Schenectady	16.09	1831
N. J.	Bordentown	Hightstown	14.00	1832
Pa.	Port Carbon	Tuscarora	9.23	1830
Del.	Newcastle	Frenchtown	16.19	1832
Md.	Baltimore	Ellicott's Mills	15.00	1830
D. C.	Washington.	Md. state line	4.00	1835
Central Northern:				
Ohio.	Sandusky	Green Spring	22.50	1838
Mich.	Toledo, O.	Adrian, Mich.	33.00	1836
Ind.	Madison	Vernon	22.00	1842
Ill.	Jacksonville	Meredosia	24.00	1839
Wis.	Milwaukee	Waukesha	21.50	1851
South Atlantic:				
Va.	Richmond	Chesterfield Mines	12.00	1831
W. Va.	Harpers Ferry.	Winchester, Va.	32.00	1836
N. C.	Petersburg, Va.	Blakely, N. C.	63.00	1833
S. C.	Charleston	West	7.00	1830
Ga.	Savannah	West	9.00	1837
Fla.	St. Joseph	Lake Wimico	8.00	1836
Gulf & Mississippi Valley:				
Ala.	Tuscumbia	Decatur	45.50	1834
Miss.	Vicksburg	Jackson	14.00	1841
Tenn.	Nashville	Murfreesborough.	30.00	1851
Ky.	Lexington	Frankfort	29.00	1835
La.	New Orleans	Lk. Pontchartrain	5.00	1831
Southwestern:				
Mo.	St. Louis	West	6.00	1852
Ark.	Memphis	West	5.00	1857
Tex.	Harrisburg	Richmond	32.00	1854
Kan.	Kansas City	Lawrence	40.00	1864
Colo.	Sheridan, Kan.	Kit Carson	87.00	1870
New Mex.	Colo. state line.	South	8.30	1878
Ind. Ter.	Seneca	Vinita	35.50	1870
Okla.	Ark. City, Kan.	Ponca	25.00	1886
Northwestern:				
Iowa.	Davenport	Muscatine	39.00	1855
Minn.	St. Paul.	St. Anthony	10.00	1862
Neb.	Omaha	West	40.00	1864
N. Dak.	Fargo	Bismarck	196.50	1873
S. Dak.	Big Sioux R.	Yankton	60.00	1873
Wyo.	Denver, Colo.	Cheyenne	106.00	1870
Mont.	Ogden, Utah	Blackfoot	160.00	1869
Pacific:				
Cal.	Sacramento	Folsom	22.50	1856
Wash.	Lower Cascade.	Upper Cascade.	6.00	1862
Ore.	Portland	Albany	80.00	1870
Nev.	Truckee, Cal.	Reno	35.00	1868
Ariz.	Yuma	Adonde	30.00	1879
Utah.	Evanston, Wyo.	Echo	36.00	1869
Idaho.	Brigham, Utah.	Franklin	61.00	1874

FROM 1861 TO 1873.

From 1848 to the breaking out of the civil war, a period of twelve years, 24,637 miles of railroad were opened, being at the rate of 2,053 miles annually. During the war the mileage constructed fell off largely, the total additions from 1861 to 1864 being only 3,237 miles, of which 133 miles were in New England, 1,235 in the Middle States, 1,434 in the Western States, 143 in the Pacific States and 329 in the Southern States, no lines of importance having been constructed in the latter section during that time. The least number of miles constructed in any one year since 1835 was in 1843, when only 159 miles were built; the greatest number of miles built up to 1864 was in 1856, when 3,643 miles were opened.

It is instructive to note how swiftly the advancing wave of railroad extension struck the most prominent sections of the country in the order of their material growth. The Atlantic States were the most rapid in their early growth, and they received the greatest impulse from the gold discoveries. After 1849, in New England, the railroad mileage doubled in twenty years; in the Middle States it doubled in eight years; in the Western States the mileage increased ten-fold in nine years, and twenty-fold in twenty years; in the Southern States the mileage quadrupled in eight years, and it is now thirty-nine times as much as in 1849. In the gold-producing states the railroad system was slow to start its development. Till 1855 there were no railways in the Pacific States. During the succeeding eight years there were less than 30 miles built, and the cost of transportation was enormous.

From 1865 until 1873 the construction of new lines of railroad progressed with unusual vigor, due in a measure to the great abundance of capital, but primarily to the undertaking of the Pacific lines of railroad under the stimulus of government aid. In this period no less than 36,359 miles were added to the country's railway ramifications, being an increase of nearly 107%. In other words, more railroads were built in these nine years than in the preceding thirty-four years.

Of the lines constructed in these years, 1,521 miles were located in New England, 5,448 in the Middle States, 9,604 —more than one-fourth—in the five Central States, north of the Ohio River and east of the Missouri, while no less than 15,578 miles were opened in the three groups of states west of the Mississippi and Missouri Rivers, the remaining 4,208 miles being distributed throughout the Southern States.

The completion of the Union Pacific R. R. on the 8th of May, 1869, and the opening of the first through transcontinental route formed thereby, has been deservedly classed as among the most potent factors in the extraordinary growth of the great West, as well as one of the strongest ties which bound the rapidly growing communities of the Pacific slope with our firmly established cities east of the Mississippi River.

FROM 1873 TO THE END OF THE CENTURY.

The disasters of 1873, resulting from the financial revulsion of that year, were followed by a long period of depression in all the industries of the country. Though in none was it more marked than in that of railway construction, yet such were the requirements of the country in the six years 1874 to 1879, there were added 16,288 miles of road, an annual average of 2,715 miles, against an average of 4,040 miles per annum during the nine years preceding.

The depression that followed the panic of 1873 extended through the years 1874-1878. During 1879 matters began to improve throughout the country, and this feeling soon became reflected through the railroads. In that year construction increased nearly 100% over the preceding year.

The following statement shows the total mileage of railroads in operation at the close of each year from 1874 to 1888, with the annual increase in mileage:

Years.	Miles in Operation.	Annual Increase, Mileage.	Years.	Miles in Operation.	Annual Increase, Mileage.
1874	72,385	2,117	1882	114,677	11,569
1875	74,096	1,711	1883	121,422	6,745
1876	76,808	2,712	1884	125,345	3,923
1877	79,082	2,274	1885	128,320	2,975
1878	81,747	2,665	1886	136,338	8,018
1879	86,556	4,809	1887	149,214	12,876
1880	93,262	6,706	1888	156,114	6,900
1881	103,108	9,846			

During these fifteen years there were built 85,846 miles of new railroad, an increase of over 122%; that is, in these 15 years were built 15,578 miles of railroad more than were built in the preceding 45 years. The first five of these fifteen comprised a period of depression, the next four years were years of unexampled activity, while the three years of 1883, 1884, and 1885 were years of hesitancy, in which no new railroad enterprise of great magnitude was begun, as was natural, after the completion in a single year (1882) of 11,600 miles of road. In 1886 there were added 8,113 miles, and in 1887, 12,982 miles, the latter surpassing the record of any previous year; and in 1888, 7,056 miles. In the three years the new construction aggregated 28,151 miles, or only 45 miles less than the extraordinary record of the three years 1881-1883, in which period 28,196 miles of new main track was built.

Since 1888 there has been a steady decline in railway construction, as shown in the appended table:

Years.	Miles New Railroad Built.	Total Railroad Mileage.	Years.	Miles New Railroad Built.	Total Railroad Mileage.
1880	6,709.00	93,262.00	1889	5,689.74	161,276.72
1881	9,677.85	103,108.00	1890	5,652.77	166,653.59
1882	11,590.52	114,677.00	1891	4,598.35	170,728.78
1883	6,818.72	121,422.00	1892	4,579.15	175,170.05
1884	3,973.71	125,345.12	1893	2,856.83	177,515.81
1885	3,124.39	128,320.49	1894	2,296.00	179,414.55
1886	8,112.58	136,337.50	1895	1,989.26	181,065.16
1887	12,982.46	149,214.45	1896	2,067.90	182,768.89
1888	7,056.19	156,114.57	1897-98.	5,360.28	186,809.69

The increase in mileage during the ten years from 1840 to 1850 was 6,203 miles, or 210%. The average mileage constructed per year in this decade equalled 620.3 miles. In the succeeding decade, 1850 to 1860, 21,605 miles were added, an average of 2,160.5 miles per year, the increase equalling nearly 240%. The next ten years, 1860 to 1870, showed an increase of only 73%, or 22,296 miles, the falling off from previous records being due to the outbreak of the war. Between 1870 and 1880, 40,374 miles were added, an increase of 76%.

In 1840 the ratio of mileage of railroads to population was one mile of road to every 7,415 inhabitants; in 1850 it was one mile to every 3,298; in 1860, one mile to 1,027; in 1870 one mile to 729; in 1880 one mile to 538; in 1890 one mile to 376; in 1895 one mile to 390, and in 1898 one mile to 401. The advance in number of inhabitants to each mile of road since 1890 is accounted for by the cessation of construction.

The expansion of the railway system of the country from a total length in 1880 of 93,262 miles to 166,654 miles in 1890, representing an increase of 73,392 miles, or nearly 80%, was one of the most remarkable achievements in the internal development of this country, where magnificent achievements have become so general as to rarely excite wonderment except among foreigners. The magnitude of the work accomplished, however, can be better comprehended when, as is shown elsewhere, the construction between 1880 and 1890 was equal to the entire construction in the 45 states from 1830 to 1875, and was 5,500 miles in excess of the aggregate mileage at the end of 1898 in the 16 states comprised in the New England, Middle, and Central Groups.

During these ten years the greatest activity in the construction of new lines of railroad was displayed, as might have been expected, in the section of the country west of the Mississippi River and east of the Rocky Mountains.

In the older and more settled states north of the Ohio and east of the Mississippi Rivers, bordering upon the great lakes and the Atlantic Coast, the increase in mileage equalled 40%. The South doubled its mileage in the same period, while the extreme Western States and the section west of the Rocky Mountains added respectively in the ten years 140 and 150% of new mileage to their railway ramifications.

It was in this decade that those Western cities that were in the line of the advance of the railway system made such extraordinary strides in their growth, commercially as well as in point of population. In New York state we find Buffalo showing an increase in population of 65%. It is scarcely necessary to say that this wonderful increase was due chiefly to the construction in the decade of three important lines of railroad with Buffalo as their terminus —the Delaware, Lackawanna & Western extension from Birmingham to Buffalo, the West Shore line paralleling the New York Central for its whole length, and the New York, Chicago & St. Louis, running from Chicago to Buffalo.

In this decade, also, we find the Erie road stretching forth to Chicago by means of the extension of its main line, under the title of the Chicago & Atlantic Ry. The completion of the Philadelphia extension of the Baltimore & Ohio was the most important addition to this system, and the subsequent efforts of the controlling powers in that company to develop the property on an imposing scale, were the chief causes that resulted in the disasters that overtook the road.

In the Central Northern States, the most important independent lines built, besides the New York, Chicago & St. Louis R. R., were the Toledo, St. Louis & Kansas City, running from Toledo to St. Louis; the extension (already referred to) of the Erie system into Chicago; the Duluth, South Shore & Atlantic, along the southern shore of Lake Superior to Sault Ste. Marie; the Minneapolis, St. Paul & Sault Ste. Marie, from the Twin Cities east to the same point; and the Chicago, Burlington & Northern, which completed the Burlington route to the metropolis of the Northwest. In all of the states of this group, the construction of this period was extensive, and many other important independent lines, some of them of considerable length, but nearly all of local importance, were built, while the older corporations, such as the Chicago, Burlington & Quincy, the Chicago & Northwestern, the St. Paul, and the Illinois Central were remarkably active in the work of building branches and extensions.

For example, between the cities of Chicago and Kansas City there were built three new lines of railroad, all by corporations of the first magnitude—the Chicago, Milwaukee & St. Paul, the Atchison, Topeka & Santa Fe, and the Chicago, St. Paul & Kansas City Railroad companies.

The great event in the Northwest in the early part of the decade was the completion of the main line of the Northern Pacific R. R., that colossal enterprise which had been begun thirteen years previously, and whose financial collapse was one of the primary causes of the great revulsion of 1873. Important as was this event, it was overshadowed by the completion, in 1883, of three other transcontinental routes in different sections of the country. While the year was yet in its infancy, the Southern Pacific and the Galveston, Harrisburg & San Antonio railroads formed a junction at El Paso, and established a route running westwardly and northwestwardly from New Orleans through the states of Louisiana, Texas, New Mexico, Arizona, and California to San Francisco.

The opening of the Northern Pacific R. R. attracted widespread attention, not only on account of the elaboration of details attending it, but for being the final completion of one of the most stupendous works ever undertaken in this country. Chartered in 1864, it was not until 1869, when the Union Pacific had been completed, that construction was actually begun. In 1873 there were completed on the eastern end 450 miles of road from Duluth, Minn., west to Bismarck, Dak.; and on the western end 105 miles from New Tacoma to Kalama, Wash. The financial disasters of that year were more than the enterprise at that stage of its existence could withstand, and, like many stronger corporations, it succumbed to the inevitable. In the succeeding years it was sold and reorganized; and when the financial storm had spent its force and the energies of the people once more asserted themselves, the Northern Pacific Railroad Co. began active arrangements towards the completion of its colossal enterprise. In the spring of 1879 construction was resumed on the west bank of the Missouri River, opposite Bismarck, and several months later, on the western division of the line at the confluence of the Columbia and Snake Rivers, in Washington Territory. The intervening gap between those points was 1,222 miles, and, until complete success was achieved by the driving of the golden

spike, on September 8, 1883, the work progressed without serious interruption.

Following closely on the opening of the Northern Pacific came the announcement of the completion of the Western Division of the Atlantic & Pacific R. R. to the Needles, on the Colorado River, where connection is made with the Southern Pacific R. R. of California, and forming, in connection with that line and the Atchison, Topeka & Santa Fe, with which connection is made at Albuquerque, N. Mex., the fourth transcontinental route. Public interest was largely centered in the accomplishment of these great works, and the full measure of success with which all were attended was of itself sufficiently responsive to justify it.

Besides these lines the other important extension in the section of the country west of the Mississippi and east of the Rocky Mountains were by the St. Paul, Minneapolis & Manitoba, now the Great Northern System, which extended its line westward to Helena. The Chicago & Northwestern was equally active in forwarding its western extension to Fort Caspar, Wyoming, the Burlington in extending its line to Denver, and more recently in a northwesterly direction, to Merino, Wyoming, and the St. Paul in securing a line to Kansas City. All of these lines added considerably to their mileage in the way of branches, etc., and a vast number of important independent lines were also constructed. But the chief event of the period in that section of the country was the great battle of the powerful railroad corporations for territorial acquisition and general aggrandizement. In the great struggle that ensued from the rivalry of the Atchison, the Missouri Pacific, the Rock Island, Burlington, and Union Pacific companies a far greater extent of mileage was added than under ordinary circumstances would have been constructed in a quarter of a century.

But little can be said in a general way of the construction west of the Rocky Mountains, in the decade from 1880 to 1890, as that prosecuted to a successful termination was mostly in the interest of the four great corporations that now practically dominate the railroad affairs of that section—the Southern Pacific and the Atchison in the Southwest; the Northern Pacific and the Union Pacific in the Northwest.

The increase of 100,226 miles in the eighteen years from the end of 1879 to the first of January, 1899, is 9,525 miles greater than the aggregate railroad mileage in operation in 1898, in Great Britain and Ireland (21,277 miles), France (22,656 miles), all Germany (28,071 miles), and Austria-Hungary (19,697 miles). It is significant as showing the wonderful activity of our people, as well as the unbounded faith of capitalists in the resources of our country.

A striking feature of the railroad building in the decade, 1880-1890, was the large number of speculative and parallel lines which were put under way and many of them completed, notably the West Shore R. R., which parallels the New York Central line for its whole length from New York to Buffalo; the "Nickel-Plate" line, which parallels the Lake Shore in like manner from Buffalo to Chicago; and the South Pennsylvania, projected to parallel the Pennsylvania R. R. between Philadelphia and Pittsburg, upon which a vast sum was expended. In some instances such lines were perhaps undertaken with a view to forcing their subsequent purchase by the older companies whose lines they sought to parallel; and in the case of the two roads first mentioned these plans met with eminent success. But their fulfilment was in the main the cause of the depression which existed during the years 1885, 1886, and 1887.

The construction of railroads in this country in the past seems to have proceeded in great waves. In recurring periods it became the absorbing passion of our people. All this is very natural. No enterprise is so seductive as a railroad for the influence it exerts, the power it gives and the hope of gain it offers. Every community, no matter how well supplied, eagerly welcomes a new line for the money its cost brings it, and the promise it offers of lower rates of transportation. When there has been a considerable pause in the construction of railroads, and the traffic of old lines, which, without rivals, keeps pace with the progress of the country, their success is predicated of every new line wherever situated, no matter how wanting in real merit it may be. In a highly excited state of the public mind the promotors of new enterprises have, for a time, everything their own way; for the argument on the other side can only be presented by the result itself. There never was a period in our history in which, in the construction and consolidation of railroads, the good sense of our people was so thoroughly at fault as in the period from 1879 up to and including 1892. There can be no doubt that the country is vastly richer and stronger than at any other period of its existence, and that there is no reason to apprehend the terrible disasters that followed the year 1892; but confidence in our vast strength led to excesses wholly disproportionate to our needs or means.

Taught by the disasters of the past, we are entering upon a more healthy period in railroad construction. It is now seen that in such states as Ohio, and even in the state of New York, no extent of additional mileage, which has not for its object the development of a particular interest, will add materially to the amount of earnings in such states, the existing mileage in these supplying all the means and facilities wanted. In such states, consequently, with the reservations made, no new mileage of any considerable extent can be constructed at an advantage at all compensating for the unproductive outlay. The same may be said of new lines built nominally to serve as carriers between the West and the East. The existing lines are capable of transporting twice or thrice the tonnage now offering or that is likely to offer itself. The result of all such new lines will be to divide business with, and thus weaken, the old; or, unable to compete, their stocks and bonds must remain comparatively valueless. Their want of success will serve to check the further construction of all undertakings of the kind. Indeed, the uncertainty which prevails as to the value of the enormous mass of stocks and bonds which have been put upon the market in the past years is exerting a very salutary influence in checking or postponing new enterprises till the results of the past can be more clearly seen.

AN AUTOMATIC COUPLER FOR ENGLISH FREIGHT CARS.

Several months ago we took occasion to discuss the question of the use of automatic couplers on English freight cars, and showed decided economical and practical advantages which would result from their use. The agitation over the Railway Prevention of Accidents Act, recently passed, has brought forward many designs for automatic couplers applicable under English conditions. The Brockelbank coupler, which we illustrate herewith, was invented nearly 30 years ago, and has been tested experimentally at different times, but until the passage of the Act above referred to the railways have paid little attention to such devices, the first cost and the difficulties incident to a transition period being considered as insuperable objections, while any practical advantages were declared to be very improbable. The great difficulty of securing united action for the adoption of any standard intercoupling devices was also a powerful deterrent, as without such action there might very probably have been various non-intercoupling automatic couplers adopted by different roads, a condition which would have been worse than the present use of a standard but inefficient non-automatic coupling. English freight cars, or "goods wagons" as they are called here, are fitted either with spring buffers or rigid buffers at each corner of the frame, the rigid buffers being extensions of the side sills beyond the end sill of the car body. The end of the drawbar forms a hook, and through the shank of this hook is a hole which permanently holds the inner link of a coupling chain. When the cars are run together, a man steps between them or stoops under the buffers, raises one of the loose chains and puts the end link on the hooked drawbar of the other car. In some cases, coupling poles or sticks are used, the man standing outside the car and raising the chain with the pole, which is rested on the buffer as a fulcrum. With moving cars, however, this is almost an dangerous as coupling by hand, as the man is liable to trip and fall when running with the car and trying to get hold of the chain with the pole.

The Brockelbank automatic coupler, which is applicable to the existing drawbars (and may be coupled to them) has a hooked bar (A) suspended by a single shackle or chain link fitted to the hole in the drawbar, whose fixed hook is shown at (B). The coupling hook (A) is inclined diagonally downward and sideways when in position for coupling. The heel of this bar passes through a shield (C) projecting below the end sill. Suspended from the sill is a hinged tumbler (D) which engages with the stem of the hooked bar, and can be raised or lowered by crank-handled rods (E) extending to each side of the car. When the switchman wishes to couple two cars, he raises the coupling hooks by means of the handles (the operation being similar to that of releasing the knuckles of M. C. B. couplers), so that the hooks slide over and engage with each other. To uncouple, one rod is turned, moving the tumbler so as to trip the stem of the bar and release the hook.

In the case of two cars coming together, one with and the other without the automatic coupler, the coupling chain of the latter can be attached to the drawbar hook (not the automatic coupling hook) of the former in the usual way. Fig. 1

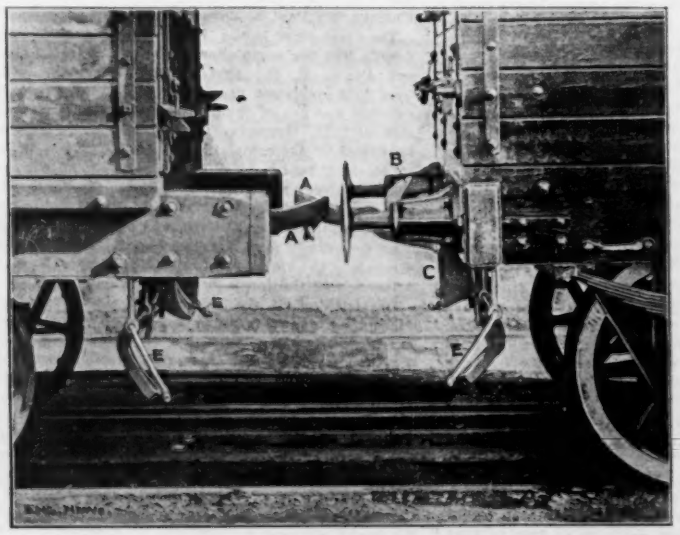


Fig. 1.—Cars Coupled.

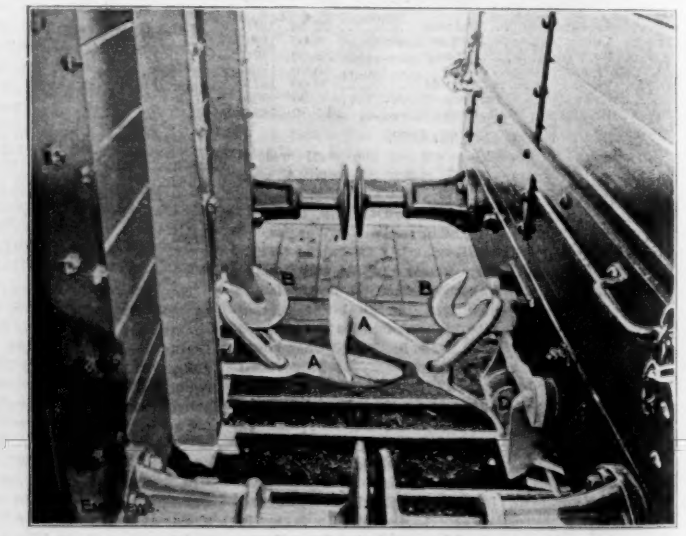


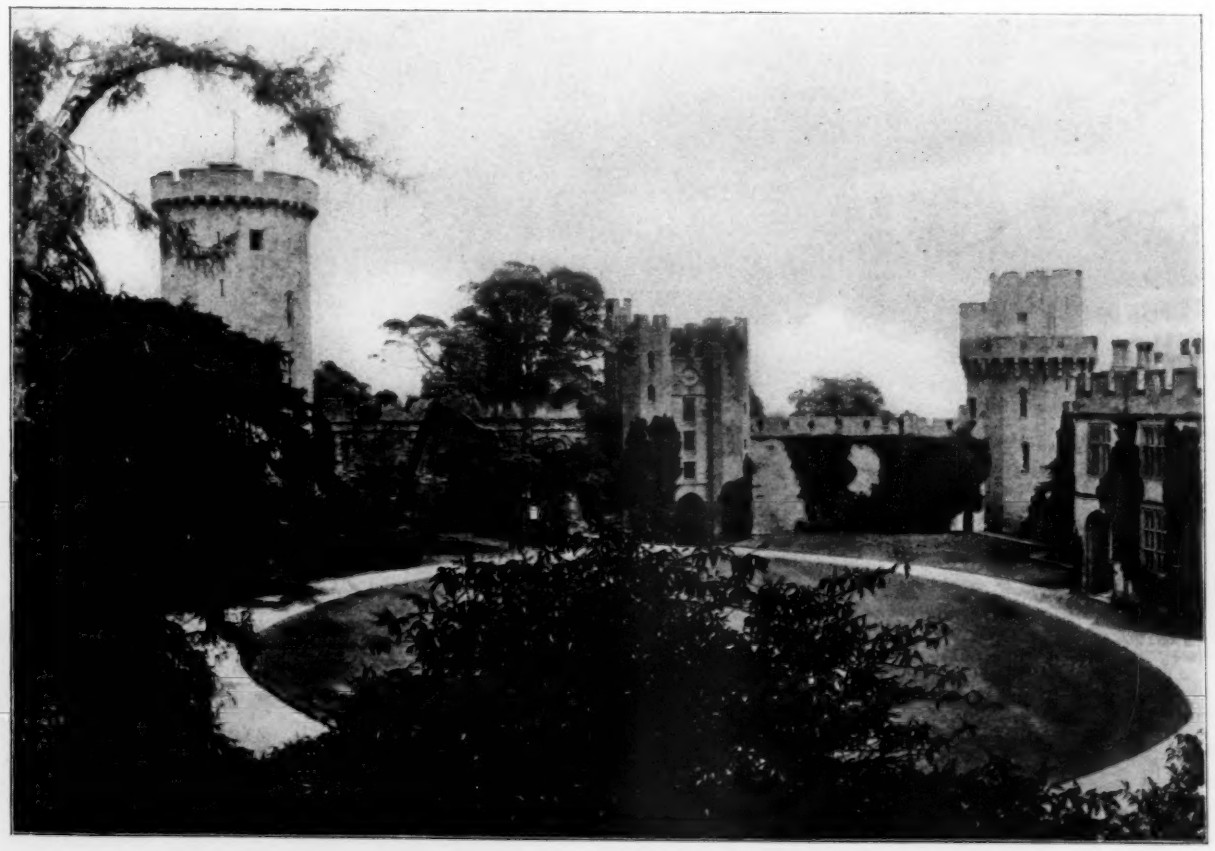
Fig. 2.—Coupler Released.

AUTOMATIC COUPLER FOR ENGLISH FREIGHT CARS. T. A. Brockelbank, Inventor.

shows cars with rigid and spring buffers coupled together with this device. Fig. 2 shows one hook raised (the tumbler just emerging from the shield) so as to clear the other. If left in this position and run against another car, the two will automatically couple by impact. This coupler is the invention of Mr. T. A. Brockelbank, 32 Queen Victoria St., London, England, who is now negotiating for its introduction on a practical scale.

Warwick

Frances Evelyn Warwick



WARWICK CASTLE, ENGLAND.

(Scene of the Reception Tendered to Members of American Engineering Societies by the Earl and Countess of Warwick, July 6, 1900.)